AD-A054 498 ARINC RESEARCH CORP ANNAPOLIS MD F/G 19/6

A RELIABILITY - MAINTAINABILITY - AVAILABILITY ASSESSMENT OF 3---ETC(U)

JAN 75 F E ERDLE N00197-74-C-0267

UNCLASSIFIED 1622-02/03-1-1345 NL

1 OF 2

AD

A054498

AD A054498

AD No.
DDC FILE COPY

Publication 1622-02/03-1-1345

FOR FURTHER TRAN

15

FINAL REPORT

A RELIABILITY - MAINTAINABILITY - AVAILABILITY ASSESSMENT OF 3-INCH 50-CALIBER RAPID FIRE TWIN GUN MOUNTS MARK 33 MOD 0 AND MOD 13

January 1975

Prepared for

NAVAL ORDNANCE STATION
LOUISVILLE, KENTUCKY 40214

under Contract N00197-74-C-0267

ARINC RESEARCH CORPORATION

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 1622-02/03-1-1345	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): A RELIABILITY - MAINTAINABILITY - AVAILABILITY ASSESSMENT OF 3-INCH 50-CALIBER RAPID FIRE TWIN GUN MOUNTS MARK 33 MOD) AND MOD 13	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER: 1622-02/03-1-1345
7. AUTHOR(s): F.E. Erdle	8. CONTRACT OR GRANT NUMBER(s): N00197-74-C-0267 new
9. PERFORMING ORGANIZATION NAME AND ADDRESS: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: NAVAL ORDNANCE STATION, LOUISVILLE, KENTUCKY 40214	12. REPORT DATE: January 1975
	13. NUMBER OF PAGES: 92
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): NAVAL ORDNANCE STATION, LOUISVILLE, KENTUCKY 40214	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNCLASSIFIED/UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

This report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the final report submitted to the Gun Systems Engineering Center (GSEC)/Naval Ordnance Station, Louisville, Kentucky, by ARINC Research Corporation under Contract N00197-74-C-0267. It presents the results of a study of the in-service reliability, maintainability, and availability of 3-Inch 50-Caliber, Rapid Fire Twin Gun Mounts Mark 33 Mod 0 and Mod 13, based on a sample of operational and maintenance data from thirteen Navy ships. The report also includes a review of certain proposed changes to the gun mounts and assesses the potential for increased reliability, maintainability, and availability that might be expect- over

ed as a result of these changes.

9 FINAL REPORT

6 # A RELIABILITY - MAINTAINABILITY - AVAILABILITY ASSESSMENT OF 3-INCH 50-CALIBER RAPID FIRE TWIN GUN MOUNTS MARK 33 MOD 0 AND MOD 13

11 Jan[redacted]1975

12 160p.

Prepared for

Naval Ordnance Station
Louisville, Kentucky 40214

under Contract N00197-74-C-0267
15

by

10 F. E. Erdle

ARINC Research Corporation
a Subsidiary of Aeronautical Radio, Inc.
2551 Riva Road
Annapolis, Maryland 21401

Publication 1622-02/03-1-1345
14

400 247

JOB

ACKNOWLEDGEMENT

To the crews of the various ships visited and to Chief Gunner's Mates Wicks and Wilson of the U.S. Amphibious Forces, Atlantic and Pacific Fleets, we express our gratitude for the earnest cooperation that made it possible to collect a good data sample for the gun mounts studied. The expert guidance of W. Nold, D. Holmes, E. Young, and D. Marshall of the Naval Ordnance Station, Louisville, in steering the study to a meaningful conclusion is especially appreciated. The efforts of personnel at the Naval Weapons Station, Concord, in revising Ordnance Logistics Information System reports to suit our special needs, as well as the many details about the reports provided by Rosemary Fassl were indispensable, and these are gratefully acknowledged.

ABSTRACT

This is the final report submitted to the Gun Systems Engineering Center (GSEC)/Naval Ordnance Station, Louisville, Kentucky, by ARINC Research Corporation under Contract N00197-74-C-0267. It presents the results of a study of the in-service reliability, maintainability, and availability of 3-Inch 50-Caliber, Rapid Fire Twin Gun Mounts Mark 33 Mod 0 and Mod 13, based on a sample of operational and maintenance data from thirteen Navy ships. The report also includes a review of certain proposed changes to the gun mounts and assesses the potential for increased reliability, maintainability, and availability that might be expected as a result of these changes.

SUMMARY

1. OBJECTIVE

The objective of this study was to estimate the reliability and maintainability of each major component of the Mark 33 Mod 0 and Mod 13 Gun Mounts. Studies available to NOSL (now the Gun Systems Engineering Center -- GSEC/NOSL) in the past have dealt only with overall gun mount indices. Under a current gun mount improvement study program, more detailed estimates of the observed indices and estimates of indices following improvements are required. On the basis of these results, the most cost-effective proposed improvements are identified.

2. DATA COLLECTED AND GENERAL ANALYSIS APPROACH

This study utilized Maintenance Data Collection System (MDCS) printouts to supply historical maintenance-event history records. These were provided, through NOSL, by the Ordnance Maintenance Management Information Center (OMMIC), Concord, California. In addition, ARINC Research personnel visited 13 ships of the Atlantic and Pacific Fleets, U.S. Amphibious Forces, to collect data from Quartermaster's Notebooks and information from ship's gun crews to provide accurate estimates of gun mount operate time and rounds cycled. These data were analyzed to allocate each maintenance action (or group of related actions), and the associated maintenance time, to each major component of the gun mounts. In this manner the information was compiled to yield an estimate of the reliability and maintainability of each gun mount's major components and the corresponding indices for the overall gun mount. The intrinsic availability of the gun mounts has been derived by using the reliability and maintainability indices.

A total of 20 Mod 0 gun mounts and a total of 12 Mod 13 gun mounts were in the data sample analyzed. The total of rounds fired in Mod 0 gun mounts was estimated to be 46,545. The estimated operate time for the Mod 0 gun mounts totaled 11,154.8 hours. The total of rounds fired in Mod 13 gun mounts was 8,165. The total of rounds cycled in Mod 13 gun mounts was estimated to be 23,802. The estimated operate time for Mod 13 gun mounts totaled 6,670.86 hours.

The calendar time period of the data sample, for all ships, was approximately 1 January 1971 to 30 June 1974. Additional statistics on the data sample are contained in Chapter Three and in the appendixes.

From NOSL descriptions of proposed loader and power-drive modifications, the expected gun mount reliability and maintainability improvement was projected. In the case of the loader, these projections were based on the observed part failures in the data sample and knowledge of the parts being retained, discarded, and modified. In the case of the power drives, where the modification proposal involved conversion of the drives to a solid-state thyristor (SCR) converter-type drive, the projected improvement was based on information from engineering articles in the *Transactions on Industry and General Applications* of the Institute of Electrical and Electronic Engineers (IGA-IEEE). SCR Converter design attributes affecting reliability, cost, and serviceability are discussed in Chapter Four.

3. RESULTS OF RELIABILITY ASSESSMENT

The functional Reliability Block Diagram of Appendix B shows the major component breakdown of the gun mounts. Counting total maintenance actions on each component and total gun mount operate hours, the Mean Time Between Actions (MTBA) was established for all major assemblies of both the Mod 0 and Mod 13 Gun Mounts.

The Mark 40 amplifier is a large assembly of unreliable major components. This assembly comprises blocks 13 through 17 and blocks 23 through 26. Notably low MTBAs for the Mark 40 and other major components of the gun mounts are listed below alongside the component titles and reliability-diagram block numbers:

Block	Component	Mod 0 MTBA (Hours)	Mod 13 MTBA (Hours)
13-17 & 23-26	Mark 40 Amplifier Assembly	69	91
3	Carriage and Shield (shield applies to Mod 13 only)	697	351
29	Loader Drive Units	930	834
30	Feed Sprockets and Drive Mechanisms	360	834
34	Transfer Tray and Shell Carriage Mechanisms	558	1668
38	Gun Housings and Mechanisms	301	953

The block-numbered items 29, 30, 34, and 38 are in the gun mount areas of slides, loaders, and housings. The MTBA indices for these items are for a system of two of each of these components in the twin gun mounts. A complete listing of major-component reliability is presented in Appendix F for Mod 0 and Appendix G for Mod 13 gun mounts. These and other low-reliability components are discussed in further detail in Chapter Three.

The observed reliability of the Mod 0 gun mount is 26.0 hours' MTBA. The comparable index for the Mod 13 gun mount is 33.0 hours' MTBA. It should be noted that these indices are derived from total actions on the gun mount and total estimated operate hours on the gun mount disregarding the time-dependent vs. rounds-dependent nature of the various components and their individual failure rates. Statistical tests of the data indicate that there is no practical significance to the numerical difference between these overall reliability indices for the Mod 0 and Mod 13 gun mounts. Therefore, the data for the Mod 0 and Mod 13 mounts can be combined, resulting in a 28.2-hour MTBA for the 3"/50 Mark 33 Gun Mount.

4. RESULTS OF MAINTAINABILITY ASSESSMENT

The maintainability index derived under this study is Mean Man-Hours to Repair (MMHTR). It was necessary to use this index because Active Maintenance Time (AMT) was not reported in the OMMIC data and Mean Time to Repair (MTTR), the usual index, cannot be obtained from the reported data. Although the OMMIC printouts used contained a column for AMT, no quantities were reported, and OMMIC verified that they did not have AMT for these gun mounts.

Among the 38 major components of the gun mounts, the number of them showing an observed MMHTR greater or equal to 12 MH is two for Mod 0, and six for Mod 13. The two Mod 0 components are the Training Gear Assembly (MMHTR = 47.2 MH) and the Loader Drive Units (MMHTR = 64.2 MH). The index for the loader drive units is for a system consisting of two units.

The two major components having the highest MMHTR on the Mod 13 gun mount are the Loader's Feed Sprockets and Drive Mechanism (MMHTR = 63.1 MH) and the Loader Drive Units (MMHTR = 62.6 MH). The index for the Training Gear Assembly of the Mod 13 gun mount was a low 1.2 MMHTR. The maintainability indices for all the major components are listed in Appendix I and discussed further in Chapter Four.

For the Mod 0 gun mount, there were a total of 429 maintenance actions, and the maintenance man-hour total was 3670.7 man-hours. Thus the overall observed Mod 0 gun mount MMHTR is 8.6 man-hours. For the Mod 13 gun mount, there were a total of 203 maintenance actions and a total of 2911.5 man-hours. The overall observed Mod 13 gun mount MMHTR is 14.3 man-hours. In the detailed listings of maintainability previously mentioned, the maintainability index is provided on each major component and the gun mount for failure and nonfailure categories of maintenance actions, as well as for the all-status category cited above.

If the assumption used by OMMIC in its Reliability-Maintainability-Availability Summary Reports (that two men are assigned for each maintenance action) is acceptable, then from the man-hours data it is concluded that the active maintenance time (AMT) for the Mod 0 gun mount is 1835.4 hours. Similarly, for the Mod 13 gun mount, the AMT is 1455.8 hours. These values of AMT and the previously stated values of number of actions yield Mean-Time-To-Repair (MTTR) indices of 4.28 hours for the Mod 0 gun mount and 7.17 hours for the Mod 13 gun mount.

5. GUN MOUNT INTRINSIC AVAILABILITY

Given the reliability and maintainability indices discussed previously, an observed intrinsic availability index was computed for each gun mount. The Intrinsic Availability (IA) index provides a good number for comparison of the two gun mounts' observed availability and projections of improved gun mount availability. IA is the MTBA divided by the sum of MTBA and MTTR. The values of observed IA are 0.859 for Mod 0 gun mounts and 0.821 for Mod 13 gun mounts.

6. COMPARISON OF ARINC RESEARCH RESULTS WITH OMMIC REPORT VALUES

An OMMIC report, *Surface Warfare Weapon Systems Reliability - Maintainability - Availability Gun Mount Summary*, covering the period July 1972 through June 1974 and showing results by calendar quarters during the period, was used for comparison of the OMMIC-reported indices with the corresponding indices derived by using the data sample of this study. Some of the index definitions used by OMMIC in their report are different from ARINC Research definitions for similar indices. The values of the indices reflect the differences in definitions and the effects of combining the data on both configurations of gun mounts. Our purpose is merely to show how the indices derived from the ARINC Research sample (according to OMMIC definitions) compare with the OMMIC reported values. The OMMIC definitions are presented in Appendix M.

Chapter Nine (Table 9-1) gives the OMMIC results for two selected quarters, along with the ARINC Research results presented in the same format as the OMMIC report. The OMMIC report summarizes results from data for all Mods of the Mark 33 gun mounts, while the ARINC Research data combine Mods 0 and 13 only. Two quarterly selections from the OMMIC report -- the latest quarter (April - June 1974) and the last calendar quarter of 1972 -- are included. There appears to have been a change, beginning with the first quarter of 1973, in the OMMIC estimator for operate time. The summary for the last quarter of 1972 yields a value of 16.6 hours for the ratio of operate hours per gun mount per month, which compares favorably with the ARINC Research value of 17.3 hours. The OMMIC quarterly summaries for 1973 and 1974 show values of the ratio ranging between 24.5 and 27.7 hours.

The 8.5-hour value of Mean Time Between Corrective Maintenance (CM) Actions for the OMMIC April - June 1974 quarter compares closely with the ARINC Research value of 7.9 hours. The OMMIC value of 4.9 hours for the October - December 1972 quarter is considerably lower.

The OMMIC value of Mean Time to Repair of 2.6 hours for the latest quarter is much lower than the ARINC Research value of 9.7 hours. However, the ARINC Research value compares closely with the OMMIC value of 8.1 hours for the last quarter of 1972.

The Mean Down Time value of 201.3 hours derived from the ARINC Research sample of data is much lower than the 301.8 hours and 404.0 hours shown by the OMMIC report for the selected quarters.

The Intrinsic Availability index (IA) for both gun mount mods combined, is 0.8802 derived from the ARINC Research data sample (computed from slightly different base data than that reported in Section 5 of this summary, as explained in Chapter Nine). This is lower than the values of 0.9236 and 0.9830 reported by OMMIC for the selected quarters.

7. ASSESSMENT OF POTENTIAL FOR GUN MOUNT IMPROVEMENT

For the proposed improvements described in Chapter Six, projections have been made of the change in reliability, maintainability, and availability that might result.

The projected change in overall gun mount reliability due to the proposed loader improvements is, for all practical purposes, negligible. According to the sample of data analyzed, a relatively large proportion of failures occurred in areas of the loader other than those cited for improvement.

The greatest gun mount reliability improvement will result from the change of the power drives to a thyristor converter drive system. The calculations show the potential for MTBA improvement to be from the currently observed value of approximately 26 hours to approximately 40 hours.

The calculations of maintainability of the improved gun mounts show that the MMHTR of the Mod 0 gun mount would increase from 8.6 MH to 10.9 MH. The MMHTR of the Mod 13 gun mount would change from 14.3 MH to 19.4 MH. The reason for the increase in the MMHTR index is that the Mark 40 amplifiers in the current-configuration gun mounts accrue a large number of maintenance actions, but they are mostly of short duration. The elimination of these Mark 40 maintenance actions provides a much smaller number of short-duration maintenance actions on the thyristor converter power drive system, while the number of actions on other parts of the system is changed very little by the other proposed modifications. This provides a smaller total number of actions having a longer average duration.

Thus this 26.9-percent increase in MMHTR for the Mod 0 gun mount and 35.5-percent increase in MMHTR for the Mod 13 gun mount are expected results. In order to assess the maintainability improvement, it is necessary to look at another index -- Maintenance Man-Hours per Operate Hour (MMH/OH).

The observed MMH/OH index for the Mod 0 gun mount is 0.3291; for the Mod 13 gun mount it is 0.4365. Adjusted values to account for the proposed improvements are 0.2590 for Mod 0 and 0.3815 for Mod 13. The resulting percentage differences of 21.3 percent for Mod 0 and 12.6 percent for Mod 13 are worthwhile improvements in each gun mount case.

The projected improvement in gun mount reliability (roughly from 26 hours to 40 hours) is not great enough, given the expected improved gun mount maintainability, to provide a large improvement in intrinsic availability. The observed IA for Mod 0 gun mounts is 0.859, compared with 0.885 projected for the improved Mod 0 gun mount, an increase of 3 percent. The observed IA for Mod 13 gun mounts is 0.822, compared with 0.840 projected for the improved Mod 13 gun mount, an increase of only 2 percent. These values are based on the previously cited MTBA results and the MTTR results computed on the basis of two men employed on each maintenance action, as discussed earlier.

8. GENERAL CONCLUSIONS AND RECOMMENDATIONS

The following general conclusions and recommendations are carried forward from Chapter Ten:

Conclusions

- The assembly of nine major components comprising the Mark 40 Amplifier has the lowest reliability of both the Mark 33 Mod 0 and Mod 13 gun mounts.
- The two loaders comprise an assembly of ten major components next to the lowest in reliability. Within the loaders, the following are low-reliability major components (2 per each gun mount):
  - Electrical Power Circuits and Parts for Loaders
  - Loader Drive Units
  - Feed Sprockets and Drive Mechanisms
  - Transfer Tray and Shell Carriage Mechanisms
- Other gun mount major components of low reliability are the following:
  - Carriage and Shield (shield applies to Mod 13 only)
  - Gun Housings and Mechanisms (2 per gun mount)

- •• Elevation Gear Assembly
- •• Gun Training Control Circuits and Control Parts
- •• Training Gear Assembly
- •• Train Drive Electrical Power Circuits and Control Parts
- •• Slides and Slide Mechanisms

- The proposed improvement to the Feed Sprockets and Drive Mechanisms of the loaders will have little impact on loader and overall gun mount reliability.
- The conversion of the power drives to solid-state thyristor converter drives would have the greatest impact on the reliability of the gun mounts. Considering reliability only, it is the most cost-effective of the two proposed improvements and may also improve gun mount capability. The loader modification is the most cost-effective from the standpoints of improved supportability and availability.
- The change in intrinsic availability of the gun mounts due to the proposed improvements would be two to three percent. However, a noticeable decrease of approximately 22 to 27 percent in the maintenance workload, given the continuation of the observed utilization rate for the gun mounts, could be expected.
- Supply-system and maintenance-procedure deficiencies are areas of frequent complaint in Deficiency Corrective Action Program (DCAP) reports.

Recommendations

- The conversion of the power drives to thyristor converter systems should be given highest priority in the gun mount improvement program because of its greater potential for improving reliability and reduction of support costs.
- In addition to improving the Feed Sprockets and Drive Mechanisms of the loaders, attention should be directed to the other low-reliability areas of the loaders cited:
  - •• Electrical Power Circuits and Parts For Loaders
  - •• Loader Drive Units
  - •• Transfer Tray and Shell Carriage Mechanisms
- Six low-reliability major components outside the area of loaders and power drives should be investigated further to determine whether cost-effective improvements can be devised:
  - •• Carriage and Shield
  - •• Training Gear Assembly
  - •• Elevation Gear Assembly
  - •• Gun Training Control Circuits and Control Parts
  - •• Slides and Slide Mechanisms
  - •• Gun Housings and Mechanisms

CONTENTS

PRECEDING PAGE BLANK

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CHAPTER ONE

INTRODUCTION

1.1 CONTRACT IDENTIFICATION AND PURPOSE

This is the final report by ARINC Research Corporation under Contract N00197-74-C-0267 with the Naval Ordnance Station, Louisville, Kentucky (NOSL). The study was conducted to assist NOSL in assessing the current reliability, maintainability, and availability of the Mark 33 Mod 0 and Mod 13 3-Inch 50 Caliber, Rapid Fire Twin Gun Mounts. The objectives of the study were the determination of the reliability and maintainability of individual major components of the gun mounts. Reliability, maintainability, and availability indices and statistics on the entire gun mount are available from the Maintenance Management Information Center (OMMIC) and other regular Navy sources, but under a current Navy gun mount improvement program additional details supplied by this study were required.

1.2 SCOPE

The study was limited to the Mark 33 Mod 0 and Mod 13 gun mount configurations since these constitute a large majority of the Mark 33 gun mounts in the Navy inventory.* Conclusions based on the study of these configurations are expected to apply as well to other configurations of the Mark 33 gun mounts. Visits were made to 13 ships of the Atlantic and Pacific Fleet, U.S. Amphibious Forces, to obtain rounds-fired data and information for estimates of gun mount operate time. Maintenance-event data were obtained from printouts of Maintenance Data Collection System (MDCS) data.

1.3 GENERAL APPROACH - TASK ASSIGNMENTS

The contracted work was carried out over a period of approximately nine months under four task assignments. The tasks are briefly described by assignment number as follows:

1. Development of a reliability model

---

*According to data supplied to ARINC Research by OMMIC, through NOSL, there are approximately 286 Mod 0 gun mounts and 114 Mod 13 gun mounts in service.

2. Data collection, data reduction, and reliability/maintainability analysis

3. Identification of practical areas for improvement of the gun mounts and evaluation of specific proposed improvements

4. Comparison of overall gun mount results with OMMIC report results

The following chapters detail the results of the data collection and analysis, and indicate the anticipated reliability, maintainability, and availability effects of certain proposed changes.

CHAPTER TWO

DCAP REPORT CATEGORIES

2.1 DEFICIENCY CORRECTIVE ACTION PROGRAM

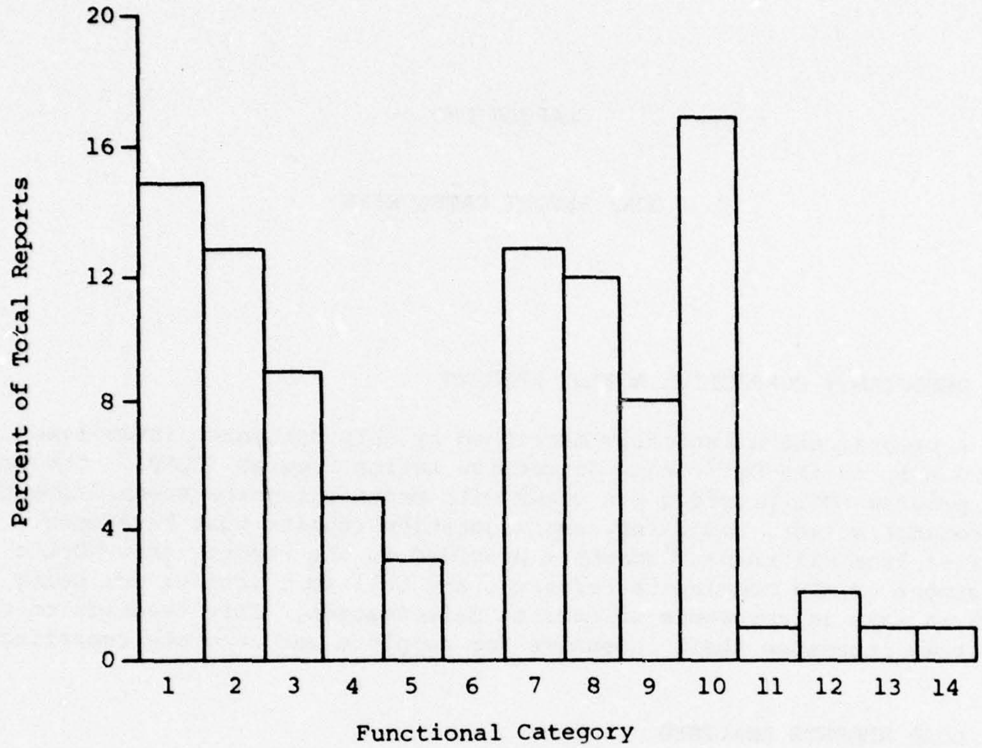
A program enthusistically mentioned by ship personnel interviewed aboard ship is the Deficiency Corrective Action Program (DCAP). Through this program NOSL provides gun crews with monthly reports summarizing the maintenance action, complaint, and suggestion reports that have been received from all ships. Comments provided in the reports show NOSL's assessment of the complaints reported, and tell what actions are being taken to make improvements or correct deficiencies. This feedback to the gun crews increases their incentive for complete and accurate reporting.

2.2 DCAP REPORTS ANALYZED

NOSL made available 72 DCAP reports published for the period January 1973 through March 1974. These were analyzed by ARINC Research to provide preliminary insight into specific gun mount problems. For purposes of this general summary, the reports were sorted by type of failure or deficiency into 14 generic functional categories. The selected categories are listed in Figure 2-1, which presents the findings for the Mod 0 and Mod 13 gun mounts combined. Twenty-four of the DCAP reports concerned the Mod 0 gun mount, and 48 concerned the Mod 13. Category 6, Mechanical Failure or Mechanical Degradation of Electromechanical Parts, has been included for comprehensiveness, although no complaints in this category were explicitly mentioned in the reports. Some of the DCAP reports contained information on more than one generic functional category, with the result that 93 category items were obtained from these data, for both gun mounts combined.

2.3 DCAP REPORT FUNCTIONAL CATEGORIES

The specific complaints in each generic functional category are detailed in the tables of Appendix A. This appendix also contains graphs, similar to Figure 2-1, for each of the gun mount configurations separately. The specific details of the complaints are discussed in Chapter Three. The purpose of this summary is to illustrate the variety and relative



1. Breakage, shearing, or degradation of mechanical parts
2. Failure or degradation of a subsystem primary function, or system adjustments required
3. Leakage of fluid seals and gaskets
4. Failure or degradation of mechanical linkage mechanisms
5. Electrical failure or electrical degradation of electromechanical parts
6. Mechanical failure or mechanical degradation of electromechanical parts
7. Supply system deficiency report or improvement recommendation
8. Failure or degradation of electrical or electronic circuits and parts
9. Design deficiency report or improvement recommendation
10. Maintenance procedures deficiency report or improvement recommendation
11. Support equipment and tools design deficiency report or improvement recommendation
12. Failure or degradation of attaching parts
13. Personnel training deficiency report or recommendation
14. Failure or degradation of support equipment and tools

Figure 2-1. MARK 33 MOD 0 AND MARK 33 MOD 13 GUN MOUNTS: DISTRIBUTION OF DCAP REPORTS BY GENERIC FUNCTIONAL CATEGORY

importance of different areas of technical expertise that will be needed under any comprehensive gun mount improvement program. Two areas of frequent complaint shown on the graph are category 7 and category 10, dealing with supply-system and maintenance-procedure deficiencies. Although these are outside the scope of, and not elaborated upon in this study, these are important areas for availability-improvement efforts.

CHAPTER THREE

RELIABILITY ASSESSMENT

3.1 THE RELIABILITY MODEL

During the initial days of this study, it was believed that a special data-collection effort to provide more data elements than are available through the Maintenance Data Collection System (MDCS) might be undertaken. Discussions were held regarding the installation of operate-time meters on a sample of gun mounts and the collection of other operational data, not reported in MDCS, identifiable to the various phases of a gun mount's operational mission. With this kind of data, a model could be used to provide a measure of mission reliability based on a standard mission definition. The reliability model, presented in detail in Appendix B, was devised with this possibility in mind. It developed later that the full range of data anticipated was not obtained, and these more elaborate features of the model could not be exercised. Finally, MDCS was relied upon for maintenance history, and information collected from ship's log books was used to provide counts of rounds fired and estimates of gun mount operate time. CASREPT and MDCS Detailed Part and Event listings were supplied for analysis by the Ordnance Maintenance Management Information Center (OMMIC), Concord, California, on request by NOSL.

The MDCS data, which omit actual time of failure and specific identification of failed-item records, cannot be used to investigate the type of failure distribution and reliability functions that are applicable in estimating reliability. However, in the event of reasonably complex assemblies, such as the major components of the gun mount, experience has shown that an exponential function is a reasonable assumption. An exponential function has been therefore assumed where calculations required a knowledge of the reliability function.

The principal feature of the model is the functional reliability block diagram showing the major components, and a list of the parts associated with each block. Reported maintenance events were allocated to the various major components during the analysis. Figure 3-1 is the block diagram reproduced for convenient reference in this chapter. The gun mounts are represented in the fully automatic mode with both guns available to fire.

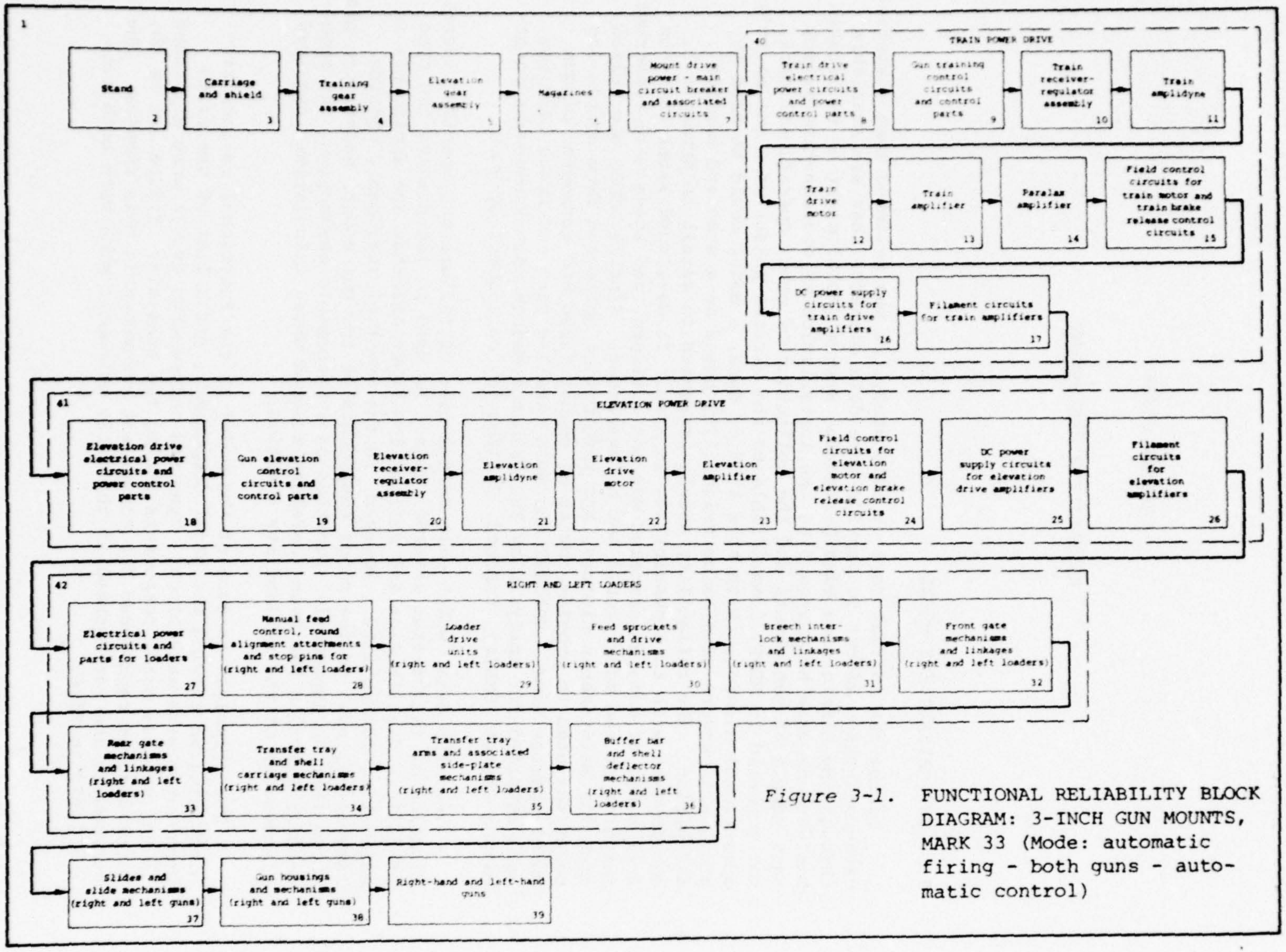


Figure 3-1. FUNCTIONAL RELIABILITY BLOCK DIAGRAM: 3-INCH GUN MOUNTS, MARK 33 (Mode: automatic firing - both guns - automatic control)

3.2 DATA COLLECTION AND REDUCTION

Ten ships of the U.S. Amphibious Force at Little Creek, Virginia, and three ships of the U.S. Amphibious Force at San Diego, California, were visited. Appendix C lists the ships and the data period over which operational information was obtained. These ships were selected by ARINC Research from those available in port from the Amphibious Forces. Although the contract required the collection of data from a total of only six ships, it was our judgment, based on the amount of information being obtained per ship, that a larger sample was necessary for good results.

An attempt was made before data collection began to determine what ships were doing the best job of MDCS reporting. It was hoped that a selection from this group might be made for data-collection purposes. Copies of the MDCS Corrective Maintenance Summary reports for 1972 and 1973 were supplied for this survey by OMMIC. From these reports, a list was made showing the ships whose ratio of maintenance events, reported on 4790/2K forms, to total events was 0.8 or greater during the years surveyed. This list is included in Appendix D. Of the ships listed, only two appeared in our data sample -- the U.S.S. AUSTIN, LPD 4, and the U.S.S. MANITOWOC, LST 1180. The MANITOWOC's MDCS data during our sample period lacked sufficient detail for our analysis and were censored from the sample.

In the data reduction, four ships (LPD 9, LSD 29, LSD 34, and LST 1180) were censored from the data sample. The decision to censor these ships was made on the basis of a comparison of their reporting index with the mean value and standard deviation of the reporting index for the total sample. The index, chosen only for this comparison, involved the number of alert exercises, and the ratio of reported maintenance actions per month.

Check sheets were used to interview and record information from the ships' crews on operation and maintenance procedures and policy for the gun mounts. Minor differences found between ships were noted and accounted for in the analysis. All available Quartermasters Notebooks were examined on each ship. From these books, the dates and time periods of all exercises that would require energizing the gun mounts were extracted. Estimates of the operate time per month and dummy rounds cycled per month during PMS and other maintenance or operating events were obtained from the gun maintenance-crew chiefs. Ship personnel supplied copies of their log sheets recording rounds fired.

The data collected from the ships were reduced to provide estimated total operate time for each gun mount. Total operate time includes the operate time indicated by the log book entries examined and the estimated operate time during maintenance and gun mount warm-up prior to exercises. The rounds-fired information was also compiled to show the rounds fired by each gun mount. The total-rounds-cycled figures include the rounds fired and the estimates by the crews of the dummy rounds cycled during maintenance and prefiring exercise of the gun mounts. The crews' estimates varied from ship to ship.

The "When Discovered" dates on the maintenance events in the MDCS printouts were used to correlate the events with the calendar period of the operate-time data. The "Status" entries in the MDCS documents were used to classify the maintenance events into failure and nonfailure categories. The same procedure was used for the maintainability data.

Descriptions of the proposed gun mount improvements, estimates of the effect of gun mount capability, and costs were supplied to ARINC Research by NOSL. These data comprise a report on the feed sprocket and drive modifications to the loader, which included lists of parts removed, new parts, and retained parts, as well as informal information about capability improvement and costs for the two proposed changes investigated. No documentation of the proposed power-drive modification was available.

The tables in Appendix E summarize, for each gun mount configuration, the overall operate-time and rounds-cycled data used for analysis. A second part of each table shows certain operational averages that facilitate judgments on the reasonableness of the data.

The calendar period of the data sample, for all ships, was approximately 1 January 1971 through 30 June 1974. After censoring of the data, a total of 20 Mod 0 gun mounts and 12 Mod 13 gun mounts remained in the data sample analyzed. The total of rounds fired in Mod 0 gun mounts was 10,357. The total of rounds cycled in Mod 0 gun mounts was estimated to be 46,545. The estimated operate time for the Mod 0 gun mounts was 11,154.8 hours. The total of rounds fired in Mod 13 gun mounts was 8,165. The total of rounds cycled in Mod 13 gun mounts was estimated to be 23,802. The estimated operate time for Mod 13 gun mounts was 6,670.86 hours.

3.3 DATA ANALYSIS APPROACH

3.3.1 Required Indices

Task 2 required determining only the following two reliability indices for the Mod 0 and Mod 13 gun mounts, and each major component of the mounts as defined in the Reliability Block Diagram:

- Mean Time Between Failures (MTBF)
- Mean Rounds Between Failures (MRBF)

In addition, the following indices were determined:

- Mean Time Between Actions (MTBA)
- Mean Rounds Between Actions (MRBA)
- Failure Rate
- Action Rate

3.3.2 Index Definitions

The MTBF and MRBF indices were derived from estimates of mount operate time, estimates of rounds cycled, and number of maintenance actions and CASREPTS where the status of the mount was reported as "nonoperative" and "reduced operative".

The MTBA and MRBA indices were derived from estimates of mount operate time, estimates of rounds cycled, and the total number of maintenance actions and CASREPTS for all mount-status categories.

It is assumed that the failures are exponentially distributed; therefore, the failure rates and action rates are the reciprocals of corresponding mean indices and are expressed as failures, or actions, per 10,000 hours, or rounds, throughout.

3.3.3 Rounds-Dependent and Time-Dependent Equipment Categories

The loaders, slides, housings, and gun barrels of the gun mounts are essentially rounds-cycled-dependent, or rounds-fired-dependent, major components; and the remaining major components are essentially time-dependent for purposes of computing reliability. In the analysis, the major components have been grouped for initial index computations according to these classifications. The adjective "apparent" is used throughout this report to clarify a statement by indicating that a reliability index has been derived for a component by using a time or rounds parameter when that component more correctly belongs to the other classification. This adjective is also used to describe overall gun mount indices derived from total actions, total operate hours, or total rounds, disregarding the basic categorizations of the major components. That is, a major change in either of the observed utilization rates (either operate time or rounds cycled and fired) would probably cause a gross shift in any reported mean value that is preceded by the word "apparent".

3.3.4 Allocating Maintenance Events Among the Major Components

The MDCS printouts were analyzed in detail. The parts used in each action, usually designated by Federal Stock Number (FSN), were identified by figure and index number in the appropriate Illustrated Parts Breakdown (IPB) book. In some cases, parts having multiple use among the major components were listed in the data without means for specifically identifying the applicable major component. However, some of the parts falling in this class were identifiable to the correct major component, and those which were not specifically identifiable were allocated to the major components according to our observation of the relative frequencies, with respect to each major component involved, of those which could be identified. This problem occurred most often with the various switch and solenoid assemblies.

As mentioned previously, the when-discovered dates on the maintenance action reports were used to associate the MDCS data with the operate-time data. These dates were also used in determining total maintenance actions and total failure actions; that is, actions on the same date on the same major component which, according to the parts used or the supporting narrative comments, could be associated with the same maintenance problem were grouped and counted as only one action. The classification of an action as a failure or nonfailure of the entire gun mount was made on the basis of the gun mount status as reported in the data.

It was observed frequently that the printout of MDCS data contained entries for which the parts listed did not agree with the statements in the narrative or the action-taken statements. The JCN number, used as a control for selecting data for the printout, does not contain a date number to distinguish a given JCN from a subsequent JCN formed by the recycling of the same digits by the maintenance control centers. Therefore, it is believed that some of the printout entries were picked up by the computer from unrelated maintenance-data files. When this happened, the decision to allocate the maintenance action to a major component was based on the narrative statement and action-taken statement in lieu of the parts entries. This happened frequently, but the narrative information usually permitted analysis to continue.

3.4 ASSESSMENT OF PRESENT-CONFIGURATION RELIABILITY

The functional reliability block diagram, Figure 3-1, shows the major component breakdown of the gun mounts. In addition to the individual major-component numbered blocks, it also shows block numbers assigned to functional groups of major components: 1, the overall gun mount; 40, train power drive; 41, elevation power drive; and 42, the right-hand and left-hand loaders combined.

3.4.1 The Least Reliable Assembly of Major Components

The Mark 40 amplifier is an important, large assembly of unreliable major components of both gun mounts. The following components, by block diagram number and title, are components of the Mark 40 amplifier assembly:

13 - Train Amplifier

14 - Parallax Amplifier

15 - Field Control Circuits for Train Motor and Train-Brake Release Control Circuits

16 - DC Power Supply Circuits for Train Drive Amplifiers

17 - Filament Circuits for Train Amplifiers

23 - Elevation Amplifier

24 - Field Control Circuits for Elevation Motor and Elevation-Brake Release Control Circuits

25 - DC Power Supply Circuits for Elevation Drive Amplifiers

26 - Filament Circuits for Elevation Amplifiers

If total maintenance actions on each of these components and total gun mount operate hours are counted, the Mean Time Between Actions (MTBA) of the Mark 40 amplifier assembly components, for the Mod 0 gun mount, ranges from a low of 338 hours for Block 13 to a high of 930 hours for Block 24. The MTBA of the overall Mark 40 assembly is 69.3 hours. Among these components on the Mod 13 gun mount, the lowest observed reliability was 371 hours for Block 15. The highest observed reliability for these components on the Mod 13 gun mount was 1,334 hours for Block 16. The MTBA of the overall Mark 40 assembly on the Mod 13 is 91.4 hours.

3.4.2 Other Low-Reliability Major Components

Other notably low MTBAs for other major components of the gun mounts are listed below alongside the component titles and reliability diagram block numbers:*

Block	Component	Apparent Mod 0 MTBA (Hours)	Apparent Mod 13 MTBA (Hours)
3	Carriage and Shield (shield applies to Mod 13 only)	697	351
29	Loader Drive Units	930	834
30	Feed Sprockets and Drive Mechanisms	360	834
34	Transfer Tray and Shell Carriage	558	1668
38	Gun Housings and Mechanisms	301	953

The block-numbered items, 29, 30, 34, and 38, above, are in the gun mount areas of slides, loaders, and housings. The apparent MTBA indices for these items are for a system of two of each of these components in a twin gun mount. Three of the components listed above are in the loaders. The loader assembly (two loaders) has an overall apparent MTBA of 121 hours for the Mod 0 and 176 hours for the Mod 13. A complete listing of major component reliability is presented in Appendix F for Mod 0 and Appendix G for Mod 13.

3.4.3 Notations on Tables in Appendixes F and G

The tables in Appendix F give the reliability indices for the major components of the Mod 0 gun mount, and the tables in Appendix G give the indices for the Mod 13 gun mount. The first two tables in each appendix

---

*These major components show low MTBA in both mount configurations, or low MTBA in one configuration, and belong to a major assembly being considered for improvement, such as the Loaders (see 34 in the list).

give the MTBA and MTBF, respectively, for the components of the gun mount that are essentially time-dependent -- i.e., the gun mount less loaders, sliders, housings, and gun barrels. The items marked with an asterisk are those having an MTBA less than 1,120 hours, which corresponds to 10 maintenance actions in the total operate time estimated for Mod 0, or 6 maintenance actions in the total operate time estimated for Mod 13 gun mounts.

The third and fourth tables in each of these appendixes provide the MRBA and MRBF, respectively, for the components of the gun mount that are essentially rounds-dependent -- i.e., the loaders, slides, housings, and gun barrels. The pair of each of these items on the gun mount are treated as one system for reliability-index purposes. This is necessary because the data as reported in the MDCS for ships do not permit accounting for them separately. The asterisks on individual items of both of these tables point out the major components having an MRBA less than approximately 5,000 rounds for Mod 0, or approximately 4,000 rounds for Mod 13.

3.4.4 Parts Replaced and Maintenance Problems in Low-Reliability Major Components

Information was obtained from the data on replaced material and actions taken to indicate the nature of the problems in the low-reliability major components. For the major components previously cited, the following subsections summarize the results of the data evaluation.*

3.4.4.1 Train Amplifier

The train amplifier has been the subject of many adjustment actions, or replacements to facilitate adjustment in the base shop. Many replacements of the associated thyrite resistors have been reported. The majority of shipboard maintenance actions involve vacuum tube replacements. Among the tube types reported replaced in the train amplifier are: 6SL7, 6H6, OD3, 6W6, 807, and 6X5 types. Only three of these, the 6SL7, 6H6, and 807 types, are actually used in this assembly.

3.4.4.2 Parallax Amplifier

The part replaced most frequently in the Parallax Amplifier is the 3C23, thyratron tube. The other tube types used, 6SL7 and 6X5, have been mentioned, but far less frequently. Like the train amplifier, the parallax amplifier is frequently adjusted or replaced to facilitate adjustment.

3.4.4.3 Field Control Circuits for Train Motor and Train-Brake Release Control Circuits

Adjustments and tube replacements describe the majority of actions on the control chassis. The unit uses 6X5, OD3, 6H6, 6SL7, and 3C23 tube types, all of which have been reported replaced.

---

*Also see Table 6-2 in Chapter Six and Appendix J for detailed listings, including part numbers, of failures in loader block diagram numbered blocks 28, 29, and 30.

3.4.4.4 DC Power Supply Circuits for Train Drive Amplifiers

The 5R4 type rectifier tubes on the power supply chassis are subjects for frequent replacement action. There are isolated incidents of relay K302 failures and a transformer T-1 failure, but these do not appear to be high-failure-rate items. Other than the tube replacement actions, the unit is simply subjected to periodic overhaul.

3.4.4.5 Elevation Amplifier

The discussion of the Train Amplifier, Subsection 3.4.4.1, applies to the elevation amplifier as well.

3.4.4.6 Field Control Circuits for Elevation Motor and Elevation-Brake Release Control Circuits

The failures in these circuits are identical in pattern to those described for the companion train-drive-associated units in Subsection 3.4.4.3. It is noted that this major component has a higher reliability than its companion. This probably results from lower power-output demand during operation.

3.4.4.7 DC Power Supply Circuits for Elevation Drive Amplifiers

The failure pattern is the same as for the Train-Drive power-supply circuits outlined in Subsection 3.4.4.4.

3.4.4.8 Carriage and Shield

The leakage of gun-slot seals on the shielded mounts is a serious problem. Shell-ejection chute-liner extensions, elevation and train limit stops, corroded or broken fire-interrupter cams, elevation securing plunger and spring, and corroded floating-shaft couplings are other problems frequently mentioned in the data.

3.4.4.9 Loader Drive Units

The data show the following part replacements: limit switches Mark 6 Mod 1, clutch adjustment spring, sliding gear shifter, gear box roller, control switch assembly, fire control solenoid, rammer drive unit clutch assembly, motors, main camshaft gate operating adjustment coupling, helical spring, shipper cam assembly shoulder pin, control mechanism assembly spring, and differential level ball bearing.

3.4.4.10 Feed Sprockets and Drive Mechanisms

Most actions on this major component are to replace the shear pin. The shear pin is provided to protect the loader drive unit from overload in the event of excessive stiffness in the loader, which can be caused by coagulation of lubricants, maladjustment, or operator error in feeding

shells. Other replacement parts include gears and lock pins in the front frame assembly, limit switches, oil seals, and stop pin springs.

3.4.4.11 Transfer Tray and Shell Carriage Mechanisms

Part replacements in this area include tray fingers, finger control links, roller cams, stripped bolts, set screws, carriage chains, and idle gear retaining rings. Warped transfer trays and other events necessitating the replacement of the entire tray or carriage assembly have occurred.

3.4.4.12 Gun Housings and Mechanisms

Areas frequently mentioned in the data that account for most of the maintenance actions are firing-pin bushings and firing pins, salvo latches, firing-circuit contacts, breech electrical wiring assemblies, extractors, and retaining rings for both sear and extractors, operating spring connector and screw, firing keys and switches on manual controls, breech-block operating chain connector and operating shaft, and breech-block stop buffer.

3.4.5 Comparison of Low-Reliability Components in Both Gun Mount Configurations

In addition to the major components discussed above, there are nine major components that show low reliability (MTBA of less than 1120 hours) on one of the gun mount configurations but not on the other. These major components, by block diagram number, are 4, 5, 8, 9, 16, 18, 27, 34, and 37. Their MTBA indices are noted in Table 3-1 along with the MTBAs of the other low-reliability major components for both gun mount configurations. This table provides a convenient summary and comparison of the low-reliability major components for both gun mount configurations.

3.4.6 Overall Gun Mount Apparent Reliability

The reliability indices and corresponding action rates for three groupings of major components of both gun mounts are given in Appendix H. The indices are given for the time-dependent group of components; the rounds-dependent loaders; the rounds-dependent slides, housings, and gun barrels; and the overall gun mount.

The MTBF of the Mark 33 Mod 0 gun was determined, from the data analyzed, to be 78 hours. The corresponding Mod 0 MRBF index is 325 rounds. The MTBF for the Mark 33 Mod 13 gun mount was shown by the data to be 61.8 hours. The Mod 13 MRBF is 220 rounds.

The Mod 0 MTBA is 26 hours, and the Mod 0 MRBA is 108 rounds. The Mod 13 MTBA is 33 hours, and the Mod 13 is 117 rounds.

While the MTBF and MRBF values cited above indicate that the Mod 0 configuration is the better gun mount, the MTBA and MRBA indices contradict this appraisal. Likewise, F-distribution statistical tests on the results,

Table 3-1. **UNRELIABLE COMPONENTS OF MARK 33 MOD O OR MARK 33 MOD 13 3-INCH 50-CALIBER GUN MOUNTS**

Reliability Diagram No.	Component Name	Mod O MTBA (Hours)	Mod 13 MTBA (Hours)
3	Carriage and Shield (Shield applies to Mod 13 only)	697	351
4	Training Gear Assembly	1,115	3,335
5	Elevation Gear Assembly	587	1,334
8	Train Drive Electrical Power Circuit and Control Parts	5,577	741
9	Gun Training Control Circuits and Control Parts	620	6,671
13	Train Amplifier	338	392
14	Parallax Amplifier	349	741
15	Field Control Circuits for Train Motor and Train Brake Release Control Circuits	429	371
16	DC Power Supply Circuits for Train Drive Amplifier	558	1,334
18	Elevation Drive Electrical Power Circuits and Power Control Parts	NA*	834
23	Elevation Amplifier	531	834
24	Field Control Circuits for Elevation Motor and Elevation Brake Release Control Circuits	930	667
25	DC Power Supply Circuits for Elevation Drive Amplifier	656	1,112
	Slides, Loaders, Housings and Gun Barrels (System of 2 Each)		
27	Electrical Power Circuits and Parts for Loaders	2,231	1,112
29	Loader Drive Units	930	834
30	Feed Sprockets and Drive Mechanisms	360	834
34	Transfer Tray and Shell Carriage Mechanisms	558	1,668
37	Slides and Slide Mechanisms	1,859	953
38	Gun Housings and Mechanisms	301	953

*NA, not applicable, indicates that there were no maintenance actions reported for this item on Mod O gun mounts.

although singularly exact with respect to the data analyzed, show contradictions when viewed collectively. Test results show that the ratio of MTBAs for the two configurations is significant, at the 0.01 probability level, while the ratio of MRBAs is not significant. Similarly, the ratio of MTBFs is not significant, while the ratio of MRBFs is significant. This nonuniformity of test results and the fact that, except in one case,* tests made in connection with the other differences shown in Appendix H indicate that they are not significant lead to the conclusion that there is no practical difference in reliability between the two gun mount configurations overall. However, it is possible that individual major-component failure-rate differences illustrated by the tables of Appendix H might lead to a preference for one configuration over the other if reliability, maintainability, cost, and suportability factors were considered together.

*The F-Test on the data for the time-dependent components shows the difference in the two MTBFs to be significant.

CHAPTER FOUR

MAINTAINABILITY AND AVAILABILITY ASSESSMENT

4.1 DATA AND DATA-ANALYSIS APPROACH

The MDCS printouts analyzed expressed repair effort only as maintenance man-hours for each recorded maintenance event. Therefore, the maintainability index derived directly from the data under this study is mean man-hours to repair (MMHTR). The usual maintainability index, mean time to repair (MTTR), cannot be determined directly from these data since the active maintenance time (AMT) per event was not reported. However, MTTR has been obtained for the overall gun mount by applying an estimating criterion used by OMMIC that two men participate in each maintenance action.

The Chief of Naval Operations, when necessary, issues a change to the Maintenance and Material Management (3M) Manual, OPNAV 43P2, modifying Appendix 18, "List of Selected Equipments". The equipments on the list are subject to more complete reporting, including AMT, on the 4790.2K maintenance action report forms. Apparently, the gun mounts under study have not been recognized on this list during the period of our data sample. Although the OMMIC printouts contained a column for AMT, no quantities were reported, and OMMIC verified that they did not have AMT for these gun mounts.

The allocations of maintenance actions to the major components, already accomplished under the reliability assessment, were followed in allocating the man-hour quantities to the major components. The CASREPTs (there were a total of 31 for Mod 0 and 15 for Mod 13) were included by exercising engineering judgment to obtain a man-hour estimate for them. These reports do not contain man-hours or AMT, but total downtime. However, 13 of the Mod 0 and 12 of the Mod 13 CASREPT events were also reported in the MDCS data. This permitted estimation of man-hours for the other CASREPT events on the basis of the actions reported by them and the man-hours reported for similar actions in the MDCS data. The man-hours for 18 Mod 0 and 3 Mod 13 CASREPT events were estimated in this manner.

4.2 MAINTAINABILITY-ASSESSMENT RESULTS

Appendix I presents the complete set of MMHTR results for each major component and the overall gun mounts.

Among the 38 major components of the gun mounts, the number showing an observed MMHTR above 12 man-hours is two for Mod 0 and six for Mod 13. The criterion of 12 man-hours has been chosen for illustrative purposes because it appears to represent a convenient on-the-job work time for two men during a work day. The Mod 0 components are the Training Gear Assembly (MMHTR = 47.2 man-hours) and the Loader Drive Units (MMHTR = 64.2 man-hours).

The two major components having the highest MMHTR on the Mod 13 gun mount are the Feed Sprockets and Drive Mechanisms of the Loaders (MMHTR = 63.1 man-hours) and the Loader Drive Units (MMHTR = 62.6 man-hours). The index for the Training Gear Assembly of the Mod 13 gun mount was a low MMHTR of 1.2 man-hours.

For the Mod 0 gun mount, there were a total of 429 maintenance actions and a total of 3670.7 maintenance man-hours. Thus the overall observed Mod 0 gun mount MMHTR is 8.6 man-hours. For the Mod 13 gun mount, there were a total of 203 maintenance actions and a total of 2911.5 man-hours. The overall observed Mod 13 gun mount MMHTR is 14.3 man-hours. In the detailed listings of maintainability, previously mentioned, the maintainability index is provided on each major component and the gun mount, for failure and non-failure categories of maintenance actions as well as for the all-status category cited in this section.

If the criterion used by OMMIC in its Reliability-Maintainability-Availability Summary Reports (that two men are assigned for each maintenance action) is acceptable, then, from the man-hours data, it is determined that the active maintenance time (AMT) for the Mod 0 gun mount is 1835.4 hours. Similarly, for the Mod 13 gun mount, the AMT is 1455.8 hours. These values of AMT and the previously stated values of number of actions yield Mean Time To Repair (MTTR) indices of 4.28 hours for the Mod 0 gun mount and 7.17 hours for the Mod 13 gun mount.

4.3 GUN MOUNT INTRINSIC AVAILABILITY

Given the reliability and maintainability indices discussed previously, an observed intrinsic-availability index was computed for each gun mount. The Intrinsic Availability (IA) index provides a number which is free from off-mount variables for comparison of the two gun mounts' observed availability and projection of improved gun mount availability. IA is the MTBA divided by the sum of MTBA and MTTR. The values of observed IA are 0.859 for Mod 0 gun mounts and 0.821 for Mod 13 gun mounts. These calculations for the two gun mount configurations are summarized on the following page.

Parameter	Mod 0	Mod 13
Estimated Active Maintenance Time (AMT)	1835.3 hours	1455.7 hours
Total, All Maintenance Actions	429.0	203.0
Mean Time to Repair (MTTR)	4.28 hours	7.17 hours
Observed Reliability (MTBA)	26.0 hours	32.9 hours
Intrinsic Availability	0.859	0.821

CHAPTER FIVE

DISCUSSION OF POWER DRIVE IMPROVEMENTS

Among the most unreliable of the gun mount components are the vacuum-tube amplifiers of the Mark 40 Amplifier Assembly. It has been suggested that the reliability of the gun mounts could be greatly improved by conversion of the power drives to solid-state thyristor (silicon controlled rectifier, SCR) converter control in lieu of the vacuum-tube amplifiers and motor-generator sets. In the current state of the art, the functions now performed by the ac-to-dc motor-generator, drive motor, field control assemblies, and parallax amplifiers of the gun mounts can be performed by a thyristor converter. It is assumed that the solid-state equipment would consist of two major components: a regulator module and a power module -- the regulator being equivalent to the control amplifiers in the present configuration, and the power module corresponding to the ac-to-dc motor-generator set.

5.1 THYRISTOR CONVERTER DESIGN ATTRIBUTES AFFECTING RELIABILITY, SERVICEABILITY, AND COST

The applicability of accepted reliability-prediction methods to the prediction of thyristor converter reliability is questionable. Therefore, it is necessary to rely on empirical estimates by persons knowledgeable in the field of thyristor converter design for estimates that we can use in later discussions of improved gun mount reliability. This section presents various factors that should be considered in a conversion of the power drives and provides an estimate of the reliability of a solid-state power-drive design. Several related papers from transactions of the Institute of Electrical and Electronics Engineers (IEEE) have been reviewed. Those found most relevant to the discussions that follow are listed, in the order of their importance, in the selected bibliography* of this report.

*Appendix N.

5.2 BRIEF DESCRIPTION OF PRESENT-CONFIGURATION DRIVES

The train and elevation drives are essentially identical, except that the train drive includes devices and circuits for parallax correction. Major components of the drive system are the drive motor, ac-to-dc motor-generator, drive-motor field control (motor-field-control assembly), generator field control (train or elevation amplifiers), filament and plate power supplies, and the operator control and power-disconnect devices.

Servomechanisms on the mount (in the receiver-regulator units) provide error signals to the field-control amplifiers when the positions of the drives are other than the command positions (from the gun fire control system in the case of automatic operation, or from the local operator control). Through appropriate feedback mechanisms, the amplifiers automatically control the power delivered to the drive motors via the motor-generator sets to reduce the error to zero as quickly and accurately as practicable within the constraints of the power drive's capability. In the train drive, the parallax amplifier provides a feedback to the receiver-regulator to effect an adjustment of the error signal, thereby compensating for parallax according to the requirements of any particular gun mount installation.

5.3 CONVERSION EQUIPMENT AND CORRESPONDING FUNCTIONS

The solid-state equipment consists of two major components: a regulator module and a power module -- the regulator being equivalent to the control amplifiers in the present configuration, and the power module corresponding to the ac-to-dc motor-generator set. Of course, the filament and plate power supplies for the vacuum-tube amplifiers would no longer be needed. The receiver-regulator of the present configuration could remain essentially unchanged. A drive motor must remain part of the converted system, but a motor of different characteristics may be necessary.

It is necessary to compare the technology of the present and proposed equipments in order to identify factors that could significantly affect the cost of developing and implementing a conversion. These factors include safety problems, isolation of the power source, isolation of high-power and low-power circuits, immunity from noise effect caused by other equipments using a common primary power source, and electromagnetic interference produced by the power drive that may adversely affect other equipments. These factors are important to achieving not only good reliability but also serviceability and adequate system performance.

5.4 SAFETY

It is important for the designer and user to recognize that dangerous voltages may exist in the solid-state equipment in functional areas where they would not be encountered in the old equipment. This possibility is a result of differences in peak operating voltages and impedances in the

new equipment, which might cause injury to a person who accidentally touches circuit parts. In view of practical size and weight constraints, the drive motor will usually be designed to consume power at a relatively high voltage since this reduces the electric current required and, consequently, the wire size and space for windings. The Mark 1 Mod 0 motor used on the present gun mount operates at 310 Vdc, 23.5 amperes, full load. It has a nominal rating of 8.5 horsepower. In the present equipment, these voltages are enclosed by the ac-to-dc motor-generator housing, drive-motor housing, and interconnecting cable conduits. In the new equipment, such voltage and current-carrying parts will be accessible to maintenance personnel in the power module among large numbers of closely spaced components on mountings and printed circuit boards. Under these circumstances, dielectric paths must be carefully designed, and observed during maintenance, with regard to peak voltages and distance between power sources and ground. Unlike the motor-generator set, the power module on the solid-state equipment will not produce a noise to provide sensory warning of danger. In addition, it will not look like the present switches, vacuum tubes, and contactors, which are recognizable as high-voltage devices. There are no general industry standards to automatically protect or warn the user of the presence of high voltages.

In power drives employing motor-generator (MG) sets, the ac and dc voltage portions of the system are completely separated. In the thyristor converter they are linked, and any device on the dc side of the system may be influenced by peak ac voltages not present in the existing system. Problems related to reliable motor commutation, insulation adequacy, and heating in solid-state control systems have been recognized and solved by motor manufacturers, but persons conditioned by past practices will not necessarily associate these problems with solid-state control devices.

5.5 REGULATOR CIRCUIT-ISOLATION PROBLEMS AFFECTING RELIABILITY

The low-energy circuits of the regulator module are more sensitive to electrical overload than other parts of the converter. This module contains many input and feedback points through which undesirable waveforms causing overloads may be introduced. Among these are points where signals are received from the power module, such as reference voltage, thyristor gate, command signal, armature voltage feedback, and armature current feedback. In addition, the primary power mains may be a source of spurious waveforms that may cause overloads in components of the regulator module.

The waveforms that can occur in the armature circuit of the motor are especially hostile to the regulator circuits. Thus means must be provided to isolate the regulator circuits to prevent leakage-path currents. Most often this is accomplished by using transformers since they provide an economic means of adjusting voltage and impedance levels. Transformers can provide excellent isolation against dc leakage. However, because of

interwinding capacitance, the transformer's isolation capability may be low for rapidly changing dc waveforms. Thus the same device may simultaneously provide excellent isolation for dc and little isolation for high frequencies, depending on conditions.

Other devices that have been used for isolation include voltage dividers, differential amplifiers, and magnetic amplifier transducers. Each of these devices has desirable and undesirable characteristics. Therefore, additional components or special devices are often needed to provide adequate isolation. This affects design costs, production costs, and schedules, but it provides safe, reliable, and serviceable equipment.

5.6 POWER-SOURCE ISOLATION

There are three reasons for using isolation in the power circuits:

1. To change distribution voltages that are incorrect for the drive systems
2. To guard against failures due to simultaneous grounds on the ac and dc sides of the system
3. To limit the voltage and current surges that can be applied to the converter

Industry standards have been developed for converters rated at 240 volts in the 5- to 75-horsepower range and 500 volts in the 15- to 500-horsepower range. The 240-volt systems operate from nominal 230-volt power sources; 500-volt systems operate from nominal 460-volt ac power sources. If the source and system voltages are different, then transformers offer the most efficient, economic means of changing the voltage.

If reliable operation is a critical consideration, a system should be able to experience temporary accidental ground without permanent failure. Simultaneous grounds on the ac and dc sides of an unisolated system can cause equipment casualty and hazardous conditions, and could result in catastrophic failure. Transformers provide an effective means of minimizing this risk.

The kVa capacities of primary power sources can be very large under surge and fault conditions. Reliability is closely associated with stress levels, both average and peak. It is reasonable to assume that a converter would be less highly stressed under unusual operating conditions if the power-source input were limited or adjusted by the circuit coupling power to the converter, making it commensurate with potential surge-limiting requirements and the normal power requirements of the equipment. Although well designed thyristor converter circuits have built-in protection against power-source voltage and current surges, it is prudent to consider this source-impedance aspect of design where reliability is important. This may not be as critical in the lower horsepower ranges, 25 horsepower or less, as it is in the higher horsepower ranges. Where the exact nature of the

electrical characteristics of the source is known, protection from surge current and voltages can be economically provided with simple choke coils to increase circuit inductance.

5.7 POWER-SOURCE NOISE EFFECTS

A thyristor converter dc motor drive may encounter power-source interference caused by other equipments. Sixty Hz sine wave harmonic distortion and notching may be caused by other motor-drive thyristors and other thyristor devices operating from the same power source. Relay and solid-state switching circuits, both inside and outside the motor-drive converter, may cause distortion, resulting in improper operation of the motor-drive thyristor control circuits under certain conditions.

Many alternatives are available to designers for eliminating these undesirable effects and improving system reliability, but they may well be ignored in low-cost or design-to-cost equipments. The equipment may be adversely affected when it is operating in the real-world environment of changing loads and transients, but the adverse effects may go undetected during an acceptance demonstration that is unrealistic.

5.8 ELECTROMAGNETIC INTERFERENCE (EMI)

The effects of the power drive on the power source can cause conducted or radiated electromagnetic interference (EMI) in other equipments. Other equipments may, as a result, experience output-signal anomalies, heating due to poorer power-utilization efficiency, or complete failure. It is necessary, therefore, that the thyristor converter design employ adequate power-source surge current and voltage limiting and control as previously discussed, power-source phase-load balance, and RF filtering of power-source lines. When properly filtered and shielded, thyristor devices will produce no harmful radiated interference outside a ten-foot radius. At shorter distances, interface with radio receivers can occur. Naturally, in reducing EMI, size and cost are increased for the sake of overall serviceability. Most important, however, is the fact that in the field maintenance crews may not be trained or experienced in the methods of troubleshooting and correcting the EMI problem.

5.9 RELIABILITY PREDICTION STANDARDS

To date, the most widely accepted standard for electronics reliability prediction is MIL-STD-217. This standard, however, deals solely with the known statistical data for certain kinds of electrical components under a range of average stresses. Transient-voltage and current-stress levels, as encountered in thyristor converter equipment, are not dealt with in MIL-STD-217.

The extra components needed to protect and isolate a thyristor converter adequately will unfavorably affect reliability predictions based on parts count according to MIL-STD-217 procedures and assumed part failure rates under steady-state conditions. However, such components are needed to protect the converter from source transients and surrounding equipment from converter-generated transients and EMI, and will improve the reliability of the overall converter.

5.10 ESTIMATE OF THYRISTOR CONVERTER RELIABILITY

As discussed previously, existing standards for reliability prediction leave much to be desired when applied to equipment of this kind. Therefore, it is expedient, in the absence of specific data for analysis, to refer to the empirical estimates of experts in the field of thyristor converter manufacturing for a credible estimate. Messrs. Haggerty, Maynard, and Koening, of the A.O. Smith Corporation (see Appendix N), estimate that systems for drives in the 5- to 500-horsepower range may be expected to have mean times between failures (MTBF) of over 20,000 hours.

It is our judgment that for military shipboard applications, a range of 5,000 to 20,000 hours would be a reasonable MTBF estimate. The wide range in the MTBF figure is justified by use conditions. The 3"/50 guns are employed on a wide variety of ships, resulting in variations of ship power sources, climate environments, maintenance-crew manning and competence, equipment for troubleshooting, and repair expertise.

5.11 PERFORMANCE CHARACTERISTICS AND CONVERSION ALTERNATIVES

Sensitive response to command signals, consistent and dependable current-limiting to prevent overloads, and the ability to reverse motor torque rapidly within machine commutation limits are performance characteristics that will contribute to mount-positioning accuracy and reduction of command reaction time.

Estimates of performance improvement, using the thyristor converter motor drive versus the present drive system, which have been informally supplied to ARINC Research by NOSL, indicate that an approximately 30-percent improvement in reaction time and approximately 100-percent improvement in position accuracy (1.5 arc seconds versus 3.0 arc seconds) should be possible.

An alternative considered by NOSL for conversion of the mounts involves retaining the present motor generator and converting only the vacuum-tube assemblies of the Mark 40 amplifier assembly to solid state. While this approach is feasible, and is less expensive than replacing the MG set, it precludes any possibility of significant improvement in gun-mount performance characteristics. Should the threat-geometry analysis show a definite requirement for improvement in position accuracy, then retention of the MG set would not be acceptable. It is our engineering judgment

that the MG set should be replaced by a solid-state control system to permit improved system performance and reduce the likelihood of incompatibility between the solid-state amplifier and the MG-set/drive-motor combination. System reliability and maintenance costs should also be improved by this change.

CHAPTER SIX

ESTIMATES OF IMPROVED GUN MOUNT RELIABILITY

Chapter Five described the potential improvements to the Power Drive subsystem. An additional change, to improve the loader mechanism of the gun, has also been suggested. The proposed modifications to the loader would (1) change the hopper assembly from a three-sprocket to a two-sprocket mechanism, (2) change the sprocket drive mechanism from the present shifting gear to a roller-cam type mechanism, and (3) make certain changes to the loader drive assembly to accommodate the new sprocket drive assembly. These changes constitute modifications of the major component designated in this report as "Feed Sprockets and Drive Mechanisms".

The potential for RMA improvement due to these proposed improvements and other alternatives is discussed in the sections that follow. It is assumed that the Mod 0 data can be used as a basis for estimating the improvement that will apply to the Mod 13 configuration as well. Previously mentioned statistical tests of the data have revealed that the reliability of the two configurations is not significantly different.

6.1 APPROACH TO ESTIMATING LOADER RELIABILITY IMPROVEMENT

The approach to estimating reliability for the improved loader includes examining the detailed list of parts replaced and actions taken as reported in the sample of maintenance data on the present configuration loader -- Mark 2 Mod 6. Then the following steps are taken:

1. Determine the currently observed maintenance-action rates for each related group of items.
2. Identify the actions that would not apply in the new design.
3. Calculate new failure rates equal to 0.1 and 0.25 times the observed rates (90-percent and 75-percent reduction of the observed rates).
4. Use the new rates, along with the observed rates in areas not affected by the change, to compute an estimated improved action rate and new mean-rounds-between-actions and mean-time-between-actions (MRBA/MTBA) indices for the improved loader (Mark 2 Mod 12).

In the results that follow, the estimated improvement indices have been computed for the additional assumption that the limit switch and solenoid assemblies of the loaders would also be improved.

6.2 RESULTS OF LOADER IMPROVEMENT ESTIMATE

The graph of Figure 6-1 shows the currently observed values and three estimated alternative values for the MRBA/MTBA indices of the loader only. The details of the calculations for these indices are given in Table 6-1. The details of the calculations for the loader action rates used in Table 6-1 are given in Table 6-2.* The sums of the action rates in Table 6-2 are included in Table 6-1, line 1.

The bars in Figure 6-1 labeled r and t show the loader's observed MRBA and MTBA indices, respectively. The other bars apply to three alternatives:

r_1, t_1 - assume that a 90-percent reduction of the action rate would apply in the areas of design improvement.

r_2, t_2 - assume that a 75-percent reduction of the action rate would apply in the areas of design improvement.

r_3, t_3 - assume that, in addition to the r_2, t_2 conditions, the action rate for the limit switch and solenoid assemblies Mark 6 Mod 1, Mark 32 Mod 0, and Mark 6 Mod 0 would also be reduced by 75 percent.

Figure 6-2 illustrates the effect of the loader alternatives, presented in Figure 6-1, on the overall gun-mount reliability. The detailed calculations supporting this graph are shown in Table 6-3. The loader action rates of Table 6-3 are carried forward from Table 6-1.

6.3 EFFECT OF THYRISTOR CONVERTER IN LIEU OF THE PRESENT AMPLIFIERS

In the Chapter Five discussion of the thyristor converter reliability, the mean time between failures of the converter was estimated to be 5,000 to 20,000 hours. It was necessary to convert these values to numbers of actions expected within the operate hours estimated for the gun mounts in the analyzed data sample, and to actions per 10,000 rounds and actions per 10,000 operate hours. If this equipment is well designed

*Although this discussion is based on the Mod 0 data, a detailed listing for Mod 13, similar to Table 6-2, is provided in Appendix J for reference purposes. It can be seen from the table in the appendix that, even though the data sample for Mod 13 is much smaller than for Mod 0, four numbers of critical parts are common to both tables. These parts are sprocket feed mechanism drive gears, shear pin, and rammer drive unit clutch parts.

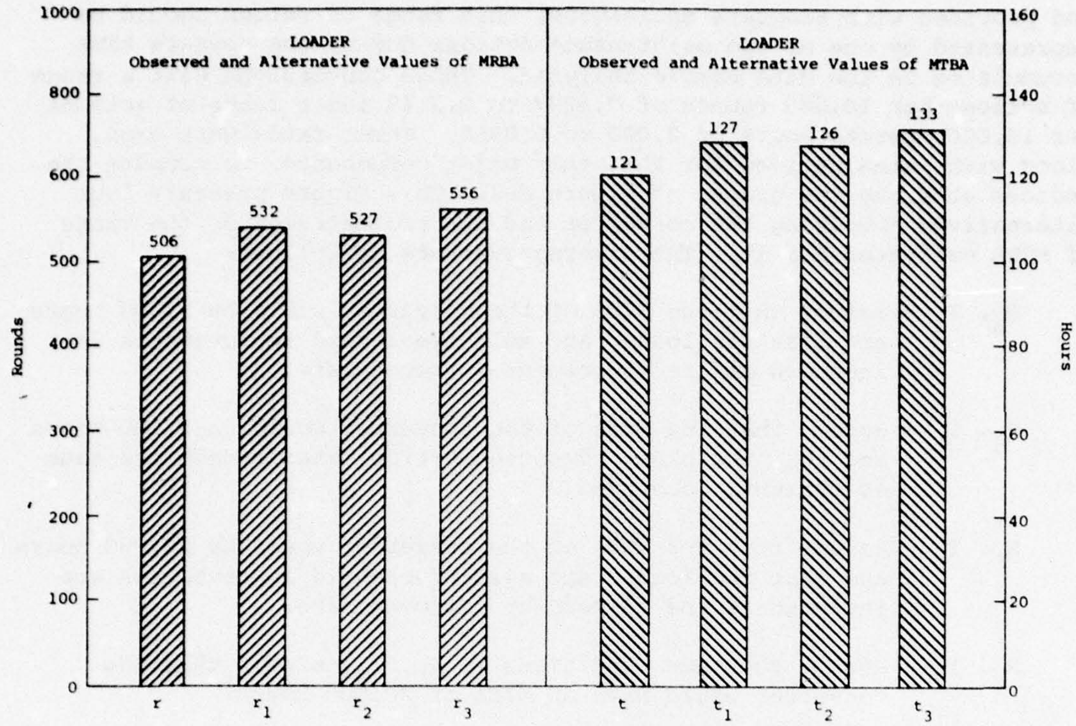


Figure 6-1. EFFECTS OF PROPOSED CHANGES ON LOADER RELIABILITY

Table 6-1. MARK 33 MOD 0 GUN MOUNT: LOADER OBSERVED AND ALTERNATIVE FAILURE RATES AND MRBA/MTBA INDICES

Item or Reliability Block Diagram Number	Action Rate or Time Index							
	A_r Observed (per 10^4 rounds)	A_t Observed (per 10^4 hours)	A_{r1} Adjusted (per 10^4 rounds)	A_{t1} Adjusted (per 10^4 hours)	A_{r2} Adjusted (per 10^4 rounds)	A_{t2} Adjusted (per 10^4 hours)	A_{r3} Adjusted (per 10^4 rounds)	A_{t3} Adjusted (per 10^4 hours)
Loader, Blocks 28-30	10.31	43.03	9.346	39.00	9.507	39.67	8.540	35.63
Loader, All Others	9.453	39.44	9.453	39.44	9.453	39.44	9.453	39.44
Total Loader	19.76	82.47	18.80	78.44	18.96	79.11	17.99	75.07
Loader MRBA or MTBA	506 rounds	121 hours	532 rounds	127 hours	527 rounds	126 hours	556 rounds	133 hours

Computations based on

Total Rounds Cycled: 46,545
Total Estimated Operate Hours: 11,154.8
Number of Observed Maintenance Actions
- **Loader Blocks 28-80:** 48
- **All Other Loader Components:** 44
- **Total Loader Actions:** 92

and provided with adequate enclosures, this range of values should be represented by one or two maintenance actions during the operate time accumulated in the data sample analyzed. These conversions give a range of actions per 10,000 rounds of 0.4297 to 0.2148 and a range of actions per 10,000 operate hours of 2.000 to 0.8965. These rates were used, along with rates derived for the other major components, to compute the indices shown by the graphs of Figure 6-3. This figure presents four alternatives involving the converter and the two extremes of the range of MTBA estimated for it. The alternatives are as follows:

R_4, T_4 - assume that the MTBA of the converter would be 5,000 hours and that the loader and switch/solenoid improvements are included at the 75-percent improved rate.

R_5, T_5 - assume that the MTBA of the converter would be 5,000 hours and that the other component-action rates remain the same as currently observed.

R_6, T_6 - assume that the MTBA of the converter would be 20,000 hours and that the loader and switch/solenoid improvements are included at the 75-percent improved rate.

R_7, T_7 - assume the same conditions as R_5, T_5, except that the converter would have an MTBA of 20,000 hours.

The detailed calculations of indices in Table 6-4 develop the values used in Figure 6-3.

6.4 IMPACT OF IMPROVEMENTS

A study of the detailed maintenance-action list in Table 6-2 shows that, on the basis of the data sample analyzed, the loader action rate is governed largely by actions in areas other than those affected by the proposed loader improvements; therefore, the graphs show little change in gun-mount reliability due to the proposed loader improvements.

The proposed thyristor converter replacement for the power drive makes the greatest impact on overall gun mount reliability. The improved converter MTBA could be approximately 40 hours compared with the 26-hour MTBA currently observed. Note that it makes little difference to the overall gun mount reliability whether the converter MTBA is 5,000 or 20,000 hours, since either value is orders of magnitude better than the loader MTBA, which is the other major area limiting the reliability of the gun mount. This is the case whether or not the proposed loader improvements are made.

Table 6-2. MARK 33 MOD 0 GUN MOUNT: DETAILED REPLACED PARTS AND ADJUSTMENTS LISTING FOR LOADER MARK 2 MOD 6 RELIABILITY DIAGRAM BLOCKS 28, 29, AND 30 WITH OBSERVED AND HYPOTHETICAL ACTION RATES FOR GUN MOUNT SYSTEM (For a System Having 2 Loaders per Gun Mount)

Loader Mod No.	No. of Observed Actions	Action Taken (Replaced or Adjusted) and Part Number	Part Number	Federal Stock Number	IPB-1566 Figure and Index	Quantity Used Per Mount (Mod 6/8 Mod 12)	Is Part or Adjustment Required on Mk 2 Mod 12? Yes	No	Action Rate: Observed A_r (Per 10^4 Rds)	Observed A_t (Per 10^4 Hrs)	Adjusted A_{r1} (Per 10^4 Rds)	Adjusted A_{t1} (Per 10^4 Hrs)	Adjusted A_{r2} (Per 10^4 Rds)	Adjusted A_{t2} (Per 10^4 Hrs)	Adjusted A_{r3} (Per 10^4 Rds)	Adjusted A_{t3} (Per 10^4 Hrs)
6	4	Replaced Switch Assy. Mk 6 Mod 1	LD167297 508127-1	5930-296-9927	4-	24-18	X		.85938	3.58590	.85938	3.58590	.85938	3.58590	.21485	.89648
6	1	Replaced Solenoid Assy. Mk 32 Mod 0	LD167298-2 512008-2	5930-259-9623	3-	4-4	X		.21485	.89648	.21485	.89648	.21485	.89648	.05371	.22412
6	1	Replaced Actuating Arm Return Spring	511961-5	(No Ref)	6-42	4-4	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Taper Pin	511961-12	(No Ref)	6-45	8-8	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Gears:							.21485	.89648	.02149	.08965	.05371	.22412	.05371	.22412
		Gear 40 Tooth	610788	1015-710-120	7-98	4-0		X								
		Gear (40 Tooth Sliding)	610789	1015-710-121	7-106	2-0		X								
6	21	Loader Adjustment or Operator Operator Error - Replaced Shear Pin	513968-4	5315-276-4050	7-73	2-2	X		4.51176	18.82598	4.51176	18.82598	4.51176	18.82598	4.51176	18.82598
6	1	Replaced Stop Pin Spring	512008-8	(No Ref)	3-17	4-4	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Covers	509570-7	5975-636-4874	4-26	18-15	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	2	Replaced Seal	(No Ref)	5330-290-1174	(No Ref)	(No Ref)	(No Ref)		.42969	1.79295	.42969	1.79295	.42969	1.79295	.42969	1.79295
6	1	Replaced External Lever Assy	512008-12	(No Ref)	3-15	4-4	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Stop Pin	511965-4	(No Ref)	5-55	4-4	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Oil Seal	33S44309-8435	5330-599-5200	13-179	2-2	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Washer & Connector	(No Ref)	(No Ref)	(No Ref)	(No Ref)	(No Ref)		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Rammer Drive Unit Clutch Assembly	511899-1	1015-384-2655	13-57	2-2	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Gear Box Roller	510066-8	1015-608-2170	12-36	2-0		X	.21485	.89648	.02149	.08965	.05371	.22412	.05371	.22412
6	1	Replaced Loader Drive Assy.	LD174436	(No Ref)	9-			X	.21485	.89648	.02149	.08965	.05371	.22412	.05371	.22412
6	1	Replaced Oil in Loader Control Assy.	(No Ref)	(No Ref)	(No Ref)	(No Ref)	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Control Switch Assy. Type N91	422187-91	5930-548-7423	33-293	2-2	X		.21485	.89648	.21485	.89648	.21485	.89648	.05371	.22412
6	2	Replaced Induction Motor Type K and Overload Relays							.42969	1.79295	.42969	1.79295	.42969	1.79295	.42969	1.79295
		Motor	709312	6105-504-0056	9-25	2-2	X									
		Relays	512009-24	1015-677-2474	31-69	4-4	X									
6	1	Replaced Adjustment Coupling	8Z1159-1	1015-319-6747	15-31	2-2	X		.21485	.89648	.21485	.89648	.21485	.89648	.21485	.89648
6	1	Replaced Spring	512414-5	5360-266-5786	11-16	2-0		X	.21485	.89648	.02149	.08965	.05371	.22412	.05371	.22412
6	1	Replaced Lever Pin	512414-6	5315-331-8577	11-20	2-0		X	.21485	.89648	.02149	.08965	.05371	.22412	.05371	.22412
6	1	Replaced Spring	1409122	5340-598-7644	13-230	2-2	X		.21485	.89648	.21485	.09648	.21485	.89648	.21485	.89648
TOTALS	48								10.31267	43.0309	9.34587	38.99674	9.50697	39.6091	8.54016	35.63496

Calculations Based On: Total Rounds Cycled 46,545 Rds.

Total Estimated Operating Hours 11,154.8

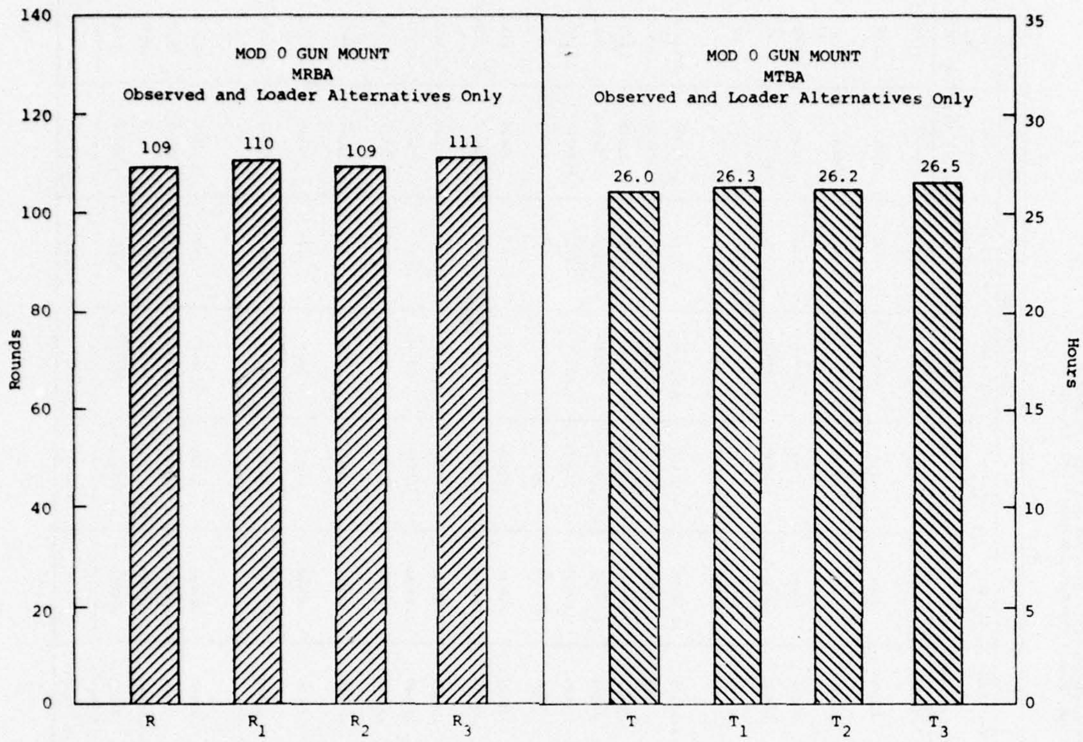


Figure 6-2. EFFECTS ON GUN MOUNT RELIABILITY OF LOADER ALTERNATIVES ONLY

Table 6-3. MARK 33 MOD 0 GUN MOUNT: OVERALL OBSERVED AND ALTERNATIVE FAILURE RATES AND MRBA/MTBA INDICES, INCLUDING LOADER ALTERNATIVES ONLY

Item	Action Rate or Time Index							
	A_R Observed (per 10^4 rounds)	A_T Observed (per 10^4 hours)	A_{R1} Adjusted (per 10^4 rounds)	A_{T1} Adjusted (per 10^4 hours)	A_{R2} Adjusted (per 10^4 rounds)	A_{T2} Adjusted (per 10^4 hours)	A_{R3} Adjusted (per 10^4 rounds)	A_{T3} Adjusted (per 10^4 hours)
Total Loader	19.76	82.47	18.80	78.44	18.96	79.11	17.99	75.07
Other Components	72.40	302.1	72.40	302.1	72.40	302.1	72.40	302.1
Overall	92.16	384.6	91.20	380.54	91.36	381.2	90.39	377.17
Overall MRBA or MTBA	109 rounds	26.0 hours	110 rounds	26.3 hours	109 rounds	26.2 hours	111 rounds	26.5 hours

Computations based on

Total Rounds Cycled: 46,545
Total Estimated Operate Hours: 11,154.8
Number of Observed Maintenance Actions
Total Loader: 92
All Other Components: 337
Total Actions: 429

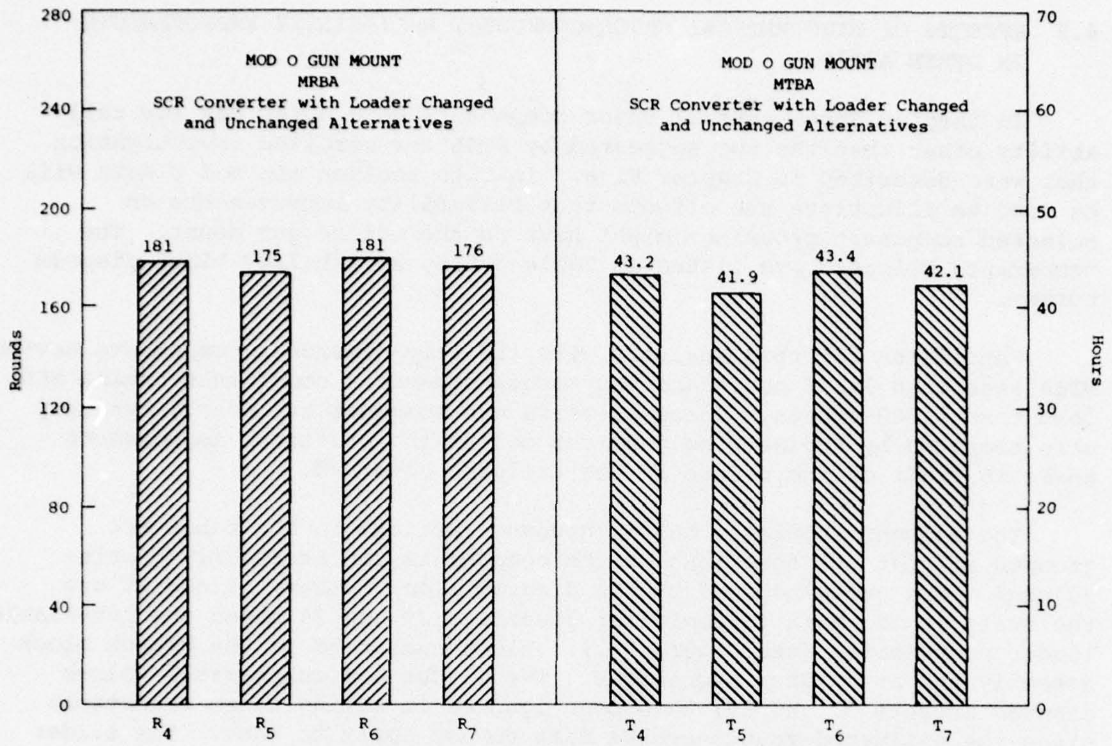


Figure 6-3. EFFECTS ON GUN MOUNT RELIABILITY OF SCR CONVERTER AND LOADER ALTERNATIVES

Table 6-4. MARK 33 MOD 0 GUN MOUNT: OVERALL OBSERVED AND LATERNATIVE FAILURE RATES AND MRBA/MTBA INDICES, INCLUDING SCR CONVERTER AND LOADER ALTERNATIVES

Item	Adjusted Action Rates							
	A_{R4} (per 10^4 rounds)	A_{T4} (per 10^4 hours)	A_{R5} (per 10^4 rounds)	A_{T5} (per 10^4 hours)	A_{R6} (per 10^4 rounds)	A_{T6} (per 10^4 hours)	A_{R7} (per 10^4 rounds)	A_{T7} (per 10^4 rounds)
Total Loader	17.99	75.07	19.76	82.47	17.99	75.07	19.76	82.47
SCR Converter	0.4297	2.000	0.4297	2.000	0.2148	0.8965	0.2148	0.8965
All Others	36.95	154.2	36.95	154.2	36.95	154.2	36.95	154.2
Overall Mount	55.37	231.3	57.14	238.7	55.15	230.2	56.92	237.6
Overall MRBA or MTBA	181 rounds	43.2 hours	175 rounds	41.9 hours	181 rounds	43.4 hours	176 rounds	42.1 hours

Computations based on

Total Rounds Cycled: 46,545
Total Estimated Operate Hours: 11,154.8
Number of Maintenance Actions
Total Loader, Observed: 92 and 92
SCR Converter, Estimated: 1 and 2
All Other Components, Observed: 172 and 172
Total Actions: 265 or 266

6.5 EFFECTS OF HYPOTHETICAL MAJOR-COMPONENT RELIABILITY IMPROVEMENTS IN OTHER AREAS

In Chapter Three several major components were cited for low reliability other than the two suggested by NOSL for detailed investigation that were described in Chapter Five. In this section the Mod 0 data will be used to illustrate the effects that reliability improvements on selected component groupings might have on the entire gun mount. The components selected are listed in Table 6-5 by reliability block diagram number.

Candidates for this analysis were the time-dependent components having MTBA less than 1,120 hours and the rounds-dependent components having MRBA less than 5,000 rounds. These criteria are somewhat arbitrary, but they were tempered by engineering judgment concerning practical improvement goals in light of the nature of the failures observed.

The columns showing total maintenance actions in the table are grouped so that the functions of the components can be readily distinguished. The group bounded by the diagram block numbers 13 and 25 are the units of the Mark 40 amplifier assembly; 29 and 34 bound the unreliable loader components (see Figure 3-1). Block number 38 is the breech block assembly and associated mechanisms. The slides and gun barrels (block diagram numbers 37 and 39) have been ignored in making these selections since the estimated-rounds-cycled data do not apply to them. The slides and barrels function only when rounds are actually fired; and barrel maintenance actions, although high in number, are mainly star-gage actions. The slides, with an MRBA of 7,760 rounds, would not have been selected in any event.

Six hypothetical improvement cases (A through F) have been designated by selecting various combinations of component groups for improvement and reducing the total maintenance actions for the selected groups to approximately ten percent of the observed numbers. The hypothetical cases are defined as follows:

Case A: Improve all selected components

Case B: Improve only the Mark 40 amplifier components found unreliable.

Case C: Remove the on-mount controls* from the design and improve all remaining components found unreliable, except the loaders and breech block.

Case D: Improve only the loaders, amplifiers, and breech block.

Case E: Remove the on-mount controls* from the design and improve only the loaders, amplifiers, and breech block.

Case F: Remove the on-mount controls from the design and improve all remaining unreliable components.

---

*The on-mount controls are the one-man control units and associated circuits. They are represented by reliability block diagram numbers 9 and 19. No. 9 (on Mod 0 gun mounts) qualified as an unreliable component; No. 19 did not qualify.

Table 6-5. UNRELIABLE COMPONENTS AND HYPOTHETICAL IMPROVEMENTS

Actions, by Case	Reliability Block Diagram Numbers															Totals		MTBA** (Hours)	Percentage Improvement
	3	4	5	9	13	14	15	16	23	24	25	29	30	34	38	This Table	All Mounts		
Observed Total Actions	16	10	19	18	33	32	26	20	21	12	17	12	31	20	37	324	429	26.0	N.A.
Hypothetical Case A, Total Actions	2	1	2	2	3	3	3	2	2	1	2	1	3	2	4	33	138	80.8	311
Hypothetical Case B, Total Actions	16	10	19	18	3	3	3	2	2	1	2	12	31	20	37	179	284	39.3	151
Hypothetical Case C, Total Actions	2	1	2	0	3	3	3	2	2	1	2	12	31	20	37	121	218*	51.2	197
Hypothetical Case D, Total Actions	16	10	19	18	3	3	3	2	2	1	2	1	3	2	4	89	194	57.5	221
Hypothetical Case E, Total Actions	16	10	19	0	3	3	3	2	2	1	2	1	3	2	4	71	176	63.4	244
Hypothetical Case F, Total Actions	2	1	2	0	3	3	3	2	2	1	2	1	3	2	4	31	136	82.0	315

*Diagram block 19, (8 observed actions) not shown here, also assumed to be zero; see text.

**Based on 11,154.8 operate hours, from data sample analyzed.

The hypothetical MTBAs and the percentage improvements of each case over the reliability observed in this sample are given in the two columns at the right-hand side of the table.

In order to provide adequate guidance for judgments regarding gun mount improvement-program actions, these cases should be considered in conjunction with maintainability, availability, and maintenance indices; cost; and the effectiveness of the system of which the gun mount is a major component.

CHAPTER SEVEN

POTENTIAL FOR IMPROVED GUN MOUNT MAINTAINABILITY AND AVAILABILITY, AND COST-EFFECTIVENESS OF PROPOSED MODIFICATIONS

In the discussion of reliability changes due to the proposed loader and power drive improvements in Chapter Six, seven alternative cases were defined to describe the effects of the expected changes. The same alternative cases, with appropriate modification of the subject index, are utilized here to illustrate the expected maintainability changes. The cases, identified by numbers corresponding to the previously used subscript numbers, are defined for maintainability-discussion purposes as follows:

1. MMH for improved areas of loaders will be 10 percent of observed MMH.
2. MMH for improved areas of loaders will be 25 percent of observed MMH.
3. MMH for improved areas of loaders and switch/solenoid actions will be 25 percent of observed MMH.
4. The number of maintenance actions for the thyristor converter (replacing the Mark 40 Amplifier Assembly and the MG Set) would be two, requiring a total of two MMH. The other improved areas would be as in Case 3.
5. The same as Case 4 except that the Case 3 component is excluded. In each instance the unimproved areas of the gun mount and the improvement areas not included under each case are assumed to remain unchanged, with values the same as observed with the data sample analyzed.

   Cases 6 and 7 were not utilized here, but their definitions are as follows:

6. The number of maintenance actions for the thyristor converter would be one, requiring 1 MMH. The other improved areas would be as in Case 3.
7. The same as Case 5, except that the number of actions and MMH would be one instead of two.

7.1 APPROACH TO MAINTAINABILITY CHANGE CALCULATIONS

In the cases requiring adjustment of the loader values, the percentage factors were applied as appropriate to the individual maintenance actions, and new adjusted totals were obtained. In the case of the thyristor converter, the adjusted values were obtained by replacing the observed number of actions by the number of actions called for in the case to be illustrated. The value of one MMH per maintenance action on the thyristor converter was established on the basis that the unit would be of modular construction. Therefore, operational maintenance would be accomplished by replacing quick-disconnect modules and major parts.

In order to illustrate clearly the improvements in maintainability, it is necessary to use an index not previously introduced. This index is mean-maintenance-man-hours-per-operate-hour (MMH/OH). In the process of analysis, the observed and adjusted values of MMH/OH and MMHTR were computed, and the differences and percentage differences between the observed and adjusted values of these index values were computed to illustrate the degree of change in maintainability.

The areas of the loader affected by the proposed NOSL modification proposal are referenced on the reliability block diagram (see Figure 3-1) as blocks 28, 29, and 30. The diagram block references for the thyrite converter are 11, 13 through 17, 21, and 23 through 26.

While the improvement-increment factors used here are somewhat arbitrary because of the lack of any specific data on which to base the factors, they serve to illustrate the impact, at the overall gun mount level, of appreciable improvement at the major-component level in the areas NOSL has suggested for improvements.

7.2 POTENTIAL GUN MOUNT MAINTAINABILITY IMPROVEMENT DUE TO PROPOSED CHANGES

Except for Case 4, which is detailed in Table 7-1, Appendix K shows the calculations of the results. The following tabulation of percentage differences of MMHTR and MMH/OH illustrate the potential improvement:

Case	Percent Difference MMHTR	Percent Difference MMH/OH
1	- 6.88	- 6.88
2	- 5.74	- 5.74
4	+17.3	-27.3
5	+26.9	-21.3

The minus signs indicate improvement of the gun mount over the currently observed values.

These values, except for Case 4, were taken from Appendix K (Table K-1), the Mod 0 results, as representative of the general improvement potential. Appendix K (Table K-2) gives the same results for Mod 13 mounts. The details for Case 4 represent the combined suggested loader and power drive improvement potential based on the more conservative of the two improvement factors used in defining the cases. The Case 4 results are presented in Table 7-1.

The results for Cases 6 and 7 defined earlier were not calculated, since it is believed that the Case 4 and 5 results represent a more conservative estimate for initial planning purposes. It can be readily seen that the Case 6 result would be approximately 1.5 times the Case 4 result, and the Case 7 result would be twice the Case 5 result.

The percentage differences in Cases 1 and 2, above, help one to judge the point of diminishing returns when considering loader improvement. The change in these percentage-difference values in going from a 90-percent improvement to a 75-percent improvement of the proposed areas is only 1.14 percent. The predominance of the proposed power drive modification in improving maintainability of the entire gun mount is evidenced by a comparison of the Case 3 and Case 5 results with the combined Case 4 results (see Appendix K).

The Case 4 results show that the MMHTR of the Mod 0 gun mount would increase from 8.6 MH to 10 MH. The MMHTR of the Mod 13 gun mount would change from 14.3 to 17.3. The reason for the increase in the MMHTR index is that the Mark 40 amplifiers in the present-configuration mounts accrue a large number of maintenance actions, but mostly of short duration. The elimination of these Mark 40 actions leaves a much smaller number of maintenance actions on the thyristor converter; and the number of actions, of relatively longer average duration, on other major components is changed very little by the other proposed improvements. Thus there remains a smaller total number of actions that have a longer average duration. Therefore, the increases in MMHTR are expected results.

In order to assess the maintainability improvement, it is necessary to examine the MMH/OH index. The values of the MMH/OH index show that the maintenance workload would be significantly reduced by the proposed modifications given the gun mount utilization represented by our data sample. The observed MMH/OH index for the Mod 0 gun mount is 0.3291, and the adjusted value is 0.2394 under Case 4. The observed MMH/OH index for the Mod 13 is 0.4365, and the Case 4 adjusted value is 0.3401. The resulting percentage differences of -27.3 percent for Mod 0 and -22.1 percent for Mod 13 would be worthwhile improvements in maintenance man-hour support required. Based on the total man-hours in our Mod 0 data sample, this represents a reduction of 1,002 MH from the total of 3,670.7 MH observed. At 160 MH per month, this represents approximately a 6-man-month reduction in effort.

Table 7-1. 3-INCH 50-CALIBER GUN MOUNTS MARK 33 MOD 0 AND MOD 13: CHANGE IN MAINTAINABILITY WITH LOADER AND POWER DRIVE IMPROVEMENTS

Mod/ Case*	Reliability Block Diagram Number	Observed Number of Actions	Adjusted Number of Actions	Observed Total MMH	Adjusted Total MMH	Observed MMHTR	Adjusted MMHTR	MMHTR Difference	Observed MMH/Op. Hr.	Adjusted MMH/Op. Hr.	MMH/Op. Hr. Difference	Percent Difference MMHTR	Percent Difference MMH/Op. Hr.
	28	5	5	6.0	3.8	1.2	0.8	-0.4	.0005	.0003	-.0002	-36.7	-36.7
	29	12	12	770.6	560.1	64.2	46.7	-17.5	.0691	.0502	-.0189	-27.3	-27.3
	30	31	31	249.7	243.5	8.1	7.9	-0.2	.0224	.0218	-.0006	-2.48	-2.48
	11,13-17, 21,23-26	165	2	783.4	2.0	4.8	1.0	-3.8	.0702	.0002	-.0700	-78.9	-99.7
	OTHER	216	216	1861.0	1861.0	8.6	8.6	0	.1668	.1668	0.	0.	0.
0/4	1-ALL MOUNT	429	266	3670.7	2670.4	8.6	10.0	+1.5	.3291	.2394	-.0897	+17.3	-27.3
	28	2	2	5.1	5.1	2.6	2.6	0.	.0008	.0008	0.	0.	0.
	29	8	8	500.7	500.6	62.6	62.6	-.01	.0751	.0750	-.0001	-.020	-.020
	30	8	8	505.1	229.1	63.1	28.6	-34.5	.0757	.0343	-.0414	-54.6	-54.6
	11,13-17, 21,23-26	74	2	368.5	2.0	5.0	1.0	-4.0	.0552	.0003	-.0549	-79.9	-99.5
	OTHER	111	111	1532.1	1532.1	13.8	13.8	0.	.2297	.2297	0.	0.	0.
13/4	1-ALL MOUNT	203	131	2911.5	2268.9	14.3	17.3	+3.0	.4365	.3401	-.0963	+20.8	-22.1

*Cases are defined in the text. Case 4 is a 25% improvement in MMH for the loaders and two 2 MMH actions for the power drives.

NOTE: MMH/OH calculations based on 11,154.8 operate hours for Mod 0 and on 6670.9 operate hours for Mod 13.

7.3 POTENTIAL FOR IMPROVED GUN MOUNT AVAILABILITY

Once again using the OMMIC criterion that there are on the average two men per maintenance action, we can convert the estimates of improved gun mount man-hours shown in Table 7-1 into an estimate of active maintenance time in order to derive an MMTR value for the improved gun mounts. The estimated AMT for the improved Mod 0 mount is 1,335.2 hours; and with 266 maintenance actions, this indicates an MTTR of 5.02 hours. The estimated AMT for the improved Mod 13 mount is 1,134.5 hours; and with 131 maintenance actions, this indicates an MTTR of 8.66 hours. By use of the observed and improvement values of MTTR and MTBA, the improved gun mount intrinsic availability can be derived and compared with the observed values. These calculations are summarized as follows:

Parameter	Mod 0			Mod 13		
	Observed	Improved	Percent Difference	Observed	Improved	Percent Difference
Estimated AMT (Hours)	1835.4	1335.2	-27.3	1455.8	1134.5	-22.1
Total Actions	429	266	-38.0	203	131	-35.5
MTTR (Hours)	4.28	5.02	+17.3	7.17	8.66	+20.8
MTBA (Hours)	26.0	43.2	+66.2	33.0	50.9	+54.2
Intrinsic Avail-ability (IA)	0.859	0.896	+ 4.31	0.821	0.855	+ 4.01

The intrinsic availability is not greatly affected by the proposed modifications. Most of the effect on IA is due to the proposed power drive modification, because of its much greater effect on MTBA compared with the proposed loader modification's effect on MTBA of the overall gun mount. If it were elected to improve the gun mounts only by improving the power drives, the resulting improved mount IAs would be 0.885 for Mod 0 and 0.840 for Mod 13. In calculating these numbers, we note from Appendix K (Table K-1), Case 5, that the improved mount AMT would be 1,444.7 hours (2889.3 ÷ 2) for Mod 0 and 1.272.5 (2545.0 ÷ 2) for Mod 13; the resulting MTTRs are 5.43 hours for Mod 0 and 9.71 hours for Mod 13. The other parameters in the computations are the same as stated in the above tabulation.

7.4 COST-EFFECTIVENESS OF PROPOSED MODIFICATIONS

Cost-effectiveness indices for the two proposed modifications are developed by computing the ratio of the cost, in dollars, to the degree of improvement, represented by the percentage difference in MTBA, MMH/OH, and IA. These results are displayed in Table 7-2. The cost figures in Table 7-2 are estimates supplied by NOSL. The percentage-difference values result from our data sample on the Mod 0 gun mounts.

These indices clearly show that the power drive modification is the more cost-effective of the two proposed modifications from the dollar-wise standpoint of mission reliability (considering $/1% MTBA difference). However, from the standpoint of supportability [$/1%(MMH/OH) difference] and availability ($/1% IA difference), the loader modification is more cost-effective. Of course, the fact that the development costs (having been provided from previous budgets) for the loader modification are not applicable under present budgetary considerations influences this outcome significantly.

If results from other improvement studies, using similar indices, were available, it would be of practical value to NOSL to compare them with these results. Then the validity of these results could be assessed and some additional cost-estimating criteria might be obtained.

Table 7-2. 3-INCH 50-CALIBER GUN MOUNTS MARK 33 MOD 0 AND MOD 13: COST-EFFECTIVENESS OF PROPOSED MODIFICATIONS PER GUN MOUNT

Modification	Estimated Design Cost (Dollars)	Estimated Installation Cost (Dollars)	Estimated Total Cost (Dollars)	MTBA Improvement (Percent)	MMH/OH Improvement (Percent)	IA Improvement (Percent)	Cost of 1-Percent MTBA Improvement (Thousands of Dollars)	Cost of 1-Percent MMH/OH Improvement (Thousands of Dollars)	Cost of 1-Percent IA Improvement (Thousands of Dollars)
Loaders	None	36,500*	36,500	7.69	5.74	0.931	4.746	6.359	39.205
Power Drives	250,000	24,748	274,748**	61.2	21.3	3.03	4.489	12.899	90.676
Both Modifi-cations	250,000	61.248	311,248	66.2	27.3	4.31	4.702	11.401	72.215

*Estimated cost of modifying two loaders per gun mount during gun mount overhaul at NOSL.

**Includes $17,000 per gun mount equipment cost plus $1,500 for cables and $6,248 for installation at a shipyard expending approximately 200 man-hours of effort.

NOTE: The percentage improvement values are percentage differences: $\frac{\text{(Improved Value - Observed Value) (100)}}{\text{Observed Value}}$

CHAPTER EIGHT

OVERHAUL SCHEDULES FOR SHIPS WITH 3"/50 GUN MOUNTS

Implementation of the Navy improvement program for the gun mounts will certainly be influenced by overhaul scheduling for the ships. This information is currently available at ARINC Research, and it is included to assist in initial planning efforts. Since unforeseen operational circumstances may require a change in overhaul assignments and dates, the information should be regarded as tentative until verified. The schedule is contained in Appendix L. It is arranged in chronological order of currently assigned overhaul periods.

8.1 SOURCES OF INFORMATION

The ships included were taken from the Mark 33 Mod 0 and Mod 13 Master Ordnance Configuration file information supplied to ARINC Research by OMMIC in March 1974. The remaining information on the schedule was abstracted from OPNAVINST 4710.29Q for Pacific Fleet ships and from OPNAVINST 4710.30Q for Atlantic Fleet ships. The date of release of the Instructions is 31 August 1974.

8.2 CLARIFICATION OF SCHEDULE HEADINGS

Most of the column headings of the schedule are self-explanatory; however, the following clarifications are needed:

- Overhaul - Operate Cycle. The number of months required for overhaul followed by the number of months of operation
- Overcycled. Indicates that if an overhaul is to be accomplished on cycle, it should be scheduled during the fiscal year indicated

8.3 SCHEDULE COMMENTS

It is noted that one ship on the schedule, the DENEBOLA (see page 10, Appendix L), does not have an overhaul period assignment during fiscal years 1974 to 1980. The first 13 overhaul periods on the schedule have already been passed, as of the date of this report. These ships have overhaul intervals of 37 to 48 months. If only the regular overhaul schedules are relied on for installation of modifications, it may be six or seven years before all ships are completed.

CHAPTER NINE

COMPARISON OF ARINC RESEARCH RESULTS WITH OMMIC-REPORTED VALUES

This chapter compares the reliability, maintainability, and availability (RMA) results obtained from the ARINC Research sample of data with the results reported by the RMA summary reports of the Ordnance Maintenance Management Information Center (OMMIC). An OMMIC summary report covering the period July 1972 through June 1974, showing results by calendar quarters during this period, was provided to ARINC Research by NOSL for this purpose.

The OMMIC report, which is included in Appendix M, contains definitions of the RMA indices and indicates their method of computation. The ARINC Research sample of data for Mod 0 and Mod 13 gun mounts combined was used to compute the same RMA indices used by OMMIC and in accordance with the OMMIC definitions. The results are tabulated in Table 9-1, along with two sets of quarterly results selected from the OMMIC report. It should be noted that the OMMIC report covers all configurations of the Mark 33 gun mount in the active equipment population as defined in the OMMIC report. When compared with the ARINC Research values presented in previous chapters, the ARINC Research values here reflect definition differences and the effect of combining data on the Mod 0 and Mod 13 configurations.

Two quarterly selections were made from the OMMIC report for use in Table 9-1 because there appears to have been a change, beginning with the first quarter of 1973, in the OMMIC estimator for operate time. It is noted from the OMMIC report that the ratio of operate hours per gun mount per month ranges between 24.5 hours and 27.7 hours for the quarters in 1973 and 1974. The last two quarters of 1972 shown on the OMMIC report yield 18.4 hours and 16.6 hours, respectively, for the ratio. A previous OMMIC report examined by ARINC Research covering the years 1971 and 1972 also shows similar lower values for the ratio. The value of the ratio obtained from the ARINC Research sample of data is 17.3 hours per gun mount per month for the Mod 0 and Mod 13 combined.

Table 9-1 shows that the value of Mean Time Between CM Actions (MTBCM) of 8.5 hours for the April - June 1974 quarter compares closely with the ARINC Research value of 7.9 hours. The OMMIC value of 4.9 hours for the October - December 1972 quarter is considerably lower.

Table 9-1. **3-INCH 50-CALIBER MARK 33 GUN MOUNTS: COMPARISON OF ARINC RESEARCH AND OMMIC RELIABILITY, MAINTAINABILITY, AND AVAILABILITY RESULTS**

Data Item	OMMIC	ARINC	OMMIC
Date Range	Apr-Jun 1974	Jan 1971 to Jun 1974	Oct-Dec 1972
Active Equipment Population (Sample Population)	381.0	32.0	232.0
Equipment Stress			
Total Estimated Operate Time (Hours)	31,223.0	17,826.7	11,567.0
Total Rounds Fired	14,479.0	18,522.0	8,282.0
Total Rounds Cycled	--	70,347.0	--
Planned Maintenance Totals (Required PMS)			
Events	20,995.0	(Note 3)	12,041.0
Man-hours	48,136.0	(Note 3)	28,897.4
MDCS Corrective Maintenance (CM) Totals			
Operational (Status 1)			
Events	170.0	381.0	72.0
Man-hours	856.8	1,727.7	295.7
AMT (Hours)	428.4	863.9	147.8
Reduced Capability (Status 3)			
CM Actions	101.0	(Note 1)	54.0
Man-hours	269.2	(Note 1)	1,136.4
AMT (Hours)	134.6	(Note 1)	568.2
Nonoperational (Status 2)			
CM Actions	92.0	(Note 1)	51.0
Man-hours	741.3	(Note 1)	565.3
AMT (Hours)	370.7	(Note 1)	282.6
CASREPTS (Not reported in MDCS)			
Events	13.0	(Note 1)	13.0
Reliability			
Total CM Actions (Status 2 & 3 and CASREPTS)	206.0	251.0	118.0
Mean Time Between CM Actions (MTBCM) where Firing Rate = 25 Rounds/Hour:	8.5	7.9	4.9
Reliability Function R(T) where: T = 1 Hour:	0.8884	0.8811	0.8155
T = 8 Hours:	0.3881	0.3631	0.1956
Maintainability			
Downtime (Hours)	--	130,867.0	--
Mean Time To Repair (MTTR) (Hours)	2.6	9.7	8.1
Number of Delays for Parts	55.0	149.0	51.0
Mean Delay Time for Parts (Hours)	681.6	1,453.0	902.4
Number of Delays for Outside Assistance	43.0	67.0	26.0
Mean Delay Time for Outside Assistance (Hours)	739.8	2,543.5	997.1
Number of Delays for Ship Operations	7.0	7.0	2.0
Mean Delay Time for Ship Operations (Hours)	683.2	5,828.0	244.0
Mean Downtime (MDT) (Hours)	301.8	201.3	404.0
Maintainability Function M(T) where			
T = 1 Hour:	0.6529	(Note 2)	0.3846
T = 3 Hours:	0.8497	(Note 2)	0.6731
Availability			
Intrinsic Availability, A(I)	0.9830	0.8802	0.9236
Operational Availability, A(O)	0.3343	(Note 3)	0.1953
Use Availability, A(U)	0.9111	(Note 3)	0.8381

NOTES:

1. **These items were not totaled separately in the ARINC Research analysis. The combined totals for all items -- nonoperational reduced capability (status 2), (status 3), and CASREPT events -- are as follows:**

   Total Events 251.0
   Total Man-hours 4854.5
   Total AMT (Hours) 2427.25

2. **Subtotals needed for this computation were not obtained from the ARINC Research data sample.**
3. **Information for computation of this index was not included in the ARINC Research data sample.**

The OMMIC Mean Time to Repair (MTTR) value of 2.6 hours for the latest quarter is much lower than the ARINC Research value of 9.7 hours. However, the ARINC Research value compares closely with the OMMIC value of 8.1 hours for the last quarter of 1972.

The 201.3-hour Mean Downtime (MDT) value derived from the ARINC Research sample of data is much lower than the 301.8 hours and 404.0 hours shown by the OMMIC report for the selected quarters.

The Intrinsic Availability index (IA) of 0.8802 derived from the ARINC Research data sample is lower than the 0.9236 and 0.9830 values reported by OMMIC for the selected quarters.

As mentioned in previous chapters, ARINC Research emphasis was on the major-component level of the gun mounts; and for this reason, information needed to compute some of the indices shown on the OMMIC summary report was not available in the ARINC Research data sample, or certain subtotals needed were not accumulated in the required manner. These instances are pointed out by the notes of Table 9-1. The format of Table 9-1 follows the OMMIC report format, except for one item: "Total Rounds Cycled", under "Equipment Stress", has been added to show this value developed from the ARINC Research data sample. The ARINC Research value for downtime hours has also been included, although the OMMIC report does not include this value, but only the line heading.

CHAPTER TEN

CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

The conclusions of ARINC Research Corporation from the data sample analyzed are as follows:

- The assembly of nine major components comprising the Mark 40 Amplifier has the lowest reliability in both the Mark 33 Mod 0 and Mark 33 Mod 13 gun mounts.
- The two loaders comprise a group of ten major components with low reliability. Within the loaders, the following are low-reliability major components (2 per gun mount):
  - Electrical Power Circuits and Parts for Loaders
  - Loader Drive Units
  - Feed Sprockets and Drive Mechanisms
  - Transfer Tray and Shell Carriage Mechanisms
- Other gun mount major components of low reliability are the following:
  - Carriage and Shield (shield applies to Mod 13 only)
  - Gun Housings and Mechanisms (2 per gun mount)
  - Elevation Gear Assembly
  - Gun Training Control Circuits and Control Parts
  - Training Gear Assembly
  - Elevation and Train Drive Electrical Power Circuits and Control Parts
  - Slides and Slide Mechanisms
- The proposed improvement to the Feed Sprockets and Drive Mechanisms of the Loaders will have little impact on loader and overall gun mount reliability.

- The conversion of the power drives to solid-state, thyristor converter drives would have the greatest impact on reliability of the gun mounts. Considering reliability only, it is the most cost-effective of the two proposed improvements, and may also improve gun mount capability. The loader modification is the most cost-effective from the standpoint of improved supportability and availability.
- The change in intrinsic availability of the gun mounts due to the proposed improvements would be 2 to 3 percent. However, a noticeable decrease of approximately 22 to 27 percent in the maintenance workload, given the continuation of the observed utilization rate for the gun mounts, can be expected to result from the proposed modifications.
- Supply-system and maintenance-procedure deficiencies are areas of frequent complaint in DCAP reports.

10.2 RECOMMENDATIONS

With an interest in assuring the best possible results from a gun improvement program, ARINC Research Corporation presents the following recommendations for consideration:

- The conversion of the power drives to thyristor converter systems should be given highest priority among the proposed modifications in the gun improvement program because of its greater potential for reliability improvement and reduction of support costs.
- In addition to improving the Feed Sprockets and Drive Mechanisms of the loaders, attention should be directed to the other low-reliability areas of the loaders cited:
  - Electrical Power Circuits and Parts for Loaders
  - Loader Drive Units
  - Transfer Tray and Shell Carriage Mechanisms
- Six low-reliability major components outside the area of loaders and power drives should be investigated further to determine whether cost-effective improvements can be devised:
  - Carriage and Shield
  - Training Gear Assembly
  - Elevation Gear Assembly
  - Gun Training Control Circuits and Control Parts
  - Slides and Slide Mechanisms
  - Gun Housings and Mechanisms

APPENDIX A

PRELIMINARY SUMMARY OF DCAP REPORTS FOR 3"/50 CALIBER MARK 33 MOD O AND MOD 13 GUN MOUNTS

(Originally submitted to NOSL Louisville 16 May 1974 by ARINC Research Corporation under Contract N00197-74-C-0267)

PRELIMINARY SUMMARY OF DCAP REPORTS
FOR 3"/50 CALIBER MARK 33 MOD 0
AND MOD 13 GUN MOUNTS

Subject of Analysis

Under the provisions of Contract N00197-74-C-0267, Task Assignment No. 2, Naval Ordnance Station, Louisville (NOSL) made available for analysis a total of 72 Deficiency Corrective Action Program (DCAP) reports published between January 1973 and March 1974.

For the purpose of this preliminary summary the DCAP reports were sorted by type of failure or deficiency into 14 generic functional categories, as listed in the accompanying tables and figures.

Findings

Forty-eight of the numbered DCAP reports concerned the Mark 33 Mod 0 gun mount. Six of these contained information on more than one generic functional category with the result that a total of 59 different category items were acquired from the report on the Mark 33 Mod 0 gun mounts.

Twenty-four of the numbered DCAP reports concerned the Mark 33 Mod 13 gun mount. Six of these contained information on more type, with the result that a total of 34 generic functional category items were acquired from the reports on the Mod 13 gun mounts.

The DCAP reports for the Mod 0 and Mod 13 gun mounts are grouped by generic category in Table 1 and Table 2, respectively. The tables show the ship or station reporting, report date, and a

brief description of the problem reported. Category totals and percentages of total categoric items are included for each group.

Figures 1 and 2 show graphically the distribution of the reports among the 14 generic categories for each of the gun mounts separately. Figure 3 combines the data on both gun mounts. In view of the similarity of the two gun mounts and the small sample of data available for each, the combined summary better reflects the expected norm for either Mod of the gun mount.

The generic functional categories encompass types of problems that are usually identified clearly; however, the items sorted under Category 2 -- Failure or Degradation of a Subsystem Primary Function, or System Adjustments Required -- include maintenance events where diagnosis of the problem was inconclusive. The number of such reports may be indicative of (1) lack of gun crew training, (2) lack of test equipment and support tools for diagnosis, (3) inadequate allocation of skill levels to gun crews, or (4) working conditions not conducive to good diagnostic effort. The available data do not permit identification of the specific cause in each instance.

No report items were classified under Mechanical Failure or Mechanical Degradation of Electro-Mechanical Parts, which was established as Category 6 for the analysis; however, given a larger sample of data, some items might have been reported in this category.

Conclusion

The information summarized above may be useful to NOSL in identifying the functional areas where additional effort is needed to increase the operational availability of the gun mounts.

TABLE 1

ARINC RESEARCH CORPORATION

3"/50 GUN MOUNT MK 33 MOD 0 DCAP SUMMARY

Report Category	DCAP Report Number	Originator Ships/Station	Originator* Date	Total Reports	Brief Problem Description
1.			Failure or Degradation of Mechanical Parts		
	T0020	LPD 0004	Jan '73		Bent housing (housing assy. spring housing)
	T0038	LPD 0004	Apr. 1 '73		Bearing wobbles (Pinion drive assembly)
	T0036	LPD 0004	Aug 14 '73	3	Broken spring
	T0010	LPD 0013	Aug 15 '73	1	Loader sides broken
	T0016	CA 0148	Jan '73		Broken teeth in EL. drive gear
	T0035	CA 0148	Apr 24 '73	2	Broken shear pins in loaders
	T0048	LSD 0033	Oct 30 '73	1	Loader Assembly Shaft damage
	T0047	DLG 0026	Oct 19 '73	1	Front gates sheared from slippage of dummy round
	T0021	LPD 0012	Jan '73	1	Sheared breech block stop pin
	T3028	LPA 0248	Jan '73	1	Sheared shell chute pin
	T3044	AF 0058	Jan '73	1	Sheared body bound bolts
	T0023	LPH 0010	Mar 10 '73	1	Loader hopper assembly front frame warped-loader jams
	Total category 1 Reports			12	(Percent of all reports = 20%)
	Total Ships/Stations Reporting			9	
2.		Failure or Degradation of a Subsystem Primary Function or System Adjustments Required			
	T3018	DLG 0019	Jan '73	1	Train subsystem - severe snapping when mount is trained
	T0030	LST 1195	Aug 24'73	1	Train subsystem - slow in train in one direction
	T0046	AE 0021	Oct '73		Train subsystem - cannot be trained in any mode
	T0050	AE 0021	Jan '73	2	Mount cannot fire in automatic mode
	T0051	AE 0023	Nov '73	1	Unable to fire the mount
	T0011	AE 0025	Mar 2 '73	1	Unable to fire in automatic mode - EL. runs away in local surface mode
	T9008	LPD 0013	Oct '73	1	Positive stop for train should be relocated
	Total category 2 Reports			7	(Percent of all reports = 11%)
	Total Ships/Stations reporting			6	
3.			Leakage of Fluid Seals and Gaskets		
	T9007	LPA 0009	May 25 '73	1	EL. power off brake solenoid failed due to leak
	T0038	LPD 0004	Apr 1'73		Leaks oil from magazine gear box
	T0038	LPD 0004	April 1'73	2	Loader front frame oil seals leaking
	Total category 3 reports			3	(Percentage of all reports = 5%)
	Total Ships/Stations Reporting			2	
4.		Failure or Degradation of Mechanical Linkage Mechanisms			
	T0013	AFS 0004	Jan '73	1	Bore clear switch operating linkage sticking
	T3016	DD 0931	Jan 19'73	1	Trigger on local AA operator's control frozen
	Total category 4 reports			2	(Percentage of all reports = 3%)
	Total ships/stations reporting			2	
5.	Electrical Failure or Electrical Degradation of Electro-Mechanical Parts				
	T3012	AFS 0003	Jan '73	1	Parallax techometer has low ground reading
	T0040	AOE 0002	Sep 13 '73		Train motor field winding grounded - corrosion in connection box
	T0054	AOE 0002	Sept 29'73	2	Train Motor Field Winding grounded - cause unknown
	Total category 5 reports			3	(Percentage of all reports = 5%)
	Total ships/stations reporting			2	
6.	Mechanical Failure or Mechanical Degradation of Electro-Mechanical Parts				
	Total category 6 Reports			0	(Percentage of all reports = 0%)

(continued)

3"/50 GUN MOUNT MK 33 MOD 0 (continued)

Report Category	DCAP Report Number	Originator Ships/Station	Originator Date	Total Reports	Brief Problem Description
7	Supply System Deficiency Report or Improvement Recommendation				
	T9015	LPH 0009	May 25 '73	1	Problem obtaining parts for magazine sprinklers
	T5004	H/PNSY	Jan '73	1	Wattmeters are not available locally
	T4001	NOCSP	Jan '73	1	Gun slot cover assemblies are not stocked in supply system
	T9013	LPH 0002	May 24 '73	1	Unable to obtain proper MIL specification for loader oil
	T9009	LSD 0029	June 4 '73	1	Would like ready-mix recoil fluid
	T8502	DLG 0033	Jan 29 '73	1	Breech closing tool
	T9021	NOSSOLANT	Mar 5 '74	1	Procedures for obtaining technical manuals
	T9020	NOSL	Mar 5 '74	1	Ordering contacts for breech block (FSN's published)
	Total category 7 reports:			8	(Percentage of all reports = 14%)
	Total Ships/Stations Reporting:			8	
8	Failure or Degradation of Electrical or Electronic Circuits and Parts				
	T9009	LSD 0029	Jan 4 '73	1	Problems with JAN 7363 and 3C23 tubes
	T0045	LSD 0033	Jan '73	1	Loss of gun firing circuit
	T9007	LPH 0009	May 25 '73	1	Brake solenoid (EL) due to leakage of seals
	T0028	LSD 0030	Jan '73	1	Train amplidyne cables burned
	T0017	DLG 0019	Jan 17 '73	1	Train amplidyne shuts off intermittently
	T0038	LPD 0004	Apr 1, '73		Mount vibrates violently when trained
	T0036	LPD 0004	Aug 14 '73	2	Stabilizing techometer output not reaching amplifier-mount responds violently to sudden OMC movements
	T3024	LPA 0248	Feb 26 '73		3C23 tube burnout
	T3023	LPA 0248	Feb 21 '73	2	Firing key shorts out
	T5001	AO 0146	Sep 17 '73	1	Frequent failures of 3C23 thyratron tubes
	Total category 8 Reports:			10	(Percentage of all reports = 17%)
	Total ships/stations reporting:			8	
9	Design Deficiency Report or Improvement Recommendation				
	T9009	LSD 0029	Jun 4 '73	1	Adjustments for motor field control amplifier awkardly located
	T0023	LPH 0010	Mar 10 '73	1	Device needed to elevate gun barrel for obstructions
	T9018	NOSL		1	Helicoil inserts in pads for jacking cables for kicking machine to be installed per ORDALT 7524 as a safety precaution
	Total category 9 Reports:			3	(Percentage of all reports = 5%)
	Total Ships/Stations Reporting			3	
10	Maintenance Procedures Deficiency Report or Improvement Recommendations				
	T5005	DE 1033	Dec 10 '73	1	Inadequate greasing schedules on MCRs
	T5008	LPH 0003	Feb 7 '74	1	Need for good wiring diagrams - loader control and firing circuits
	T8501	LSD 0033	Aug 22 '73	1	Procedures for use of hydraulic pressure gages
	T8503	LST 1186	Sep 17 '73	1	FSN needed for hand operated hydraulic power unit

(Continued)

3"50 GUN MOUNT MK 33 MOD 0 (continued)

Report Category	DCAP Report Number	Originator Ships/Stations	Originators Date	Total Reports	Brief Problem Description
10 (Continued)	Maintenance Procedures Deficiency Report or Improvement Recommendation				
	T9009	LSD 0029	Jun 4 '73	1	3C23 Tubes - NOSL suggested replacing tubes in pairs
	T9014	LPH 0002	May 24 '73	1	OP 1562 procedures for troubleshooting train and elevation amplifiers difficult (since they require too much "jumping around" - NOSL says skill level requirements and APL being reviewed.
	T9022	NOSL	Mar 5 '74	1	Amplification of narratives on Maintenance Reports using 4790/2K forms is highly desirable
	T9017	NOSL	Sept 30 '74	1	NAVORDINST 9730.1 issued Aug 9, 11, to designate NOSL as only authorized activity for firing cut-out cam cutting in order to maintain uniformity of cams.
	Total Category 10 Reports:			8	(Percentage of all reports = 14%)
	Total Ships/Stations Reporting:			8	
11	Support Equipment and Tools Design Deficiency Report or Improvement Recommendation				
	T8503	LST 1186	Sep 17 '73	1	In response to ship's request for an FSN on the hand operated hydraulic power unit (pump model P-3014) NOSL responded that FSN not available; The barrel spring compressor tool is being modified by ORDALT to make it applicable to both shielded and unshielded mounts.
	Total Category 11 Reports:			1	(Percentage of all reports = 2%)
	Total Ships/Stations Reporting:			1	
12	Failure or Degradation of Attaching Parts				
	Total Category 12 Reports:				(Percentage of all reports = 0%)
13	Personnel Training Deficiency Report or Improvement Recommendation				
	T9013	LPH 0002	May 24 '73	1	"Most problems with loaders are due to personnel problems." - NOSL requested specific problems
	Total Category 13 Reports:			1	(Percentage of all reports = 2%)
	Total Ships/Stations Reporting:			1	
14.	Failure or Degradation of Support Equipment and Tools				
	T3014	AFS 0006	Jan 20'73	1	Nuts need to be replaced on jacking out of battery rods (ref. spring compressor tool 8-2-978 or 8-2-3506 guide rod nuts).
	Total Category 14 Reports			1	(Percentage of all reports = 2%)
	Total Ships/Stations Reporting:			1	
	Total DCAP numbered Reports:			48	
	No. of Multiple Category Reports:			11	
	Total Generic Function Reports:			59	

*Where the day of the month is not given the date is the date of publication by the DCAP instead of the originating ship's date.

TABLE 2

ARINC RESEARCH CORPORATION

3"/50 GUN MOUNT MK 33 MOD 13 SUMMARY

Report Category	DCAP Report Number	Originator Ships/Station	Originator Date	Total Reports	Brief Problem Description
1		Failure or Degradation of Mechanical Parts			
	T4002	LST 1190	Sept 14 '73	1	Windows on gunshield translucent due to bubbling
	T3038	LSD 0036	Jan 4, '73	1	Shell chute badly bent
	Total Category 1 Reports:			2	
	Total Ships/Station Reporting:			2	
2		Failure or Degradation of a Subsystem Primary Functions, or System Adjustments Required			
	T3036	DE 1022	Feb 9 '73	1	Train centering pin inoperative
	T0043	AOR 0003	Oct 12 '73	1	Mount does not function in automatic control
	T0059	AOE 0004	Nov 20 '73	1	Mount runaway - stops failed causing cable damage
	T0024	LST 1179	Feb 7 '73	1	Mount oscillates in train and EL under local control
	T0025	LST 1195	Apr 4 '73	1	Left gun's loader frequently blows fuse (possible bent shaft in loader)
	Total Category 2 Reports:			5	
	Total Ships/Stations Reporting:			5	
3		Leakage of Fluid Seals and Gaskets			
	T5009	LST 1192	Jan 14 '74	1	Ventillation cover leaks - recommend install/petcock
	T9006	LST 1196	June 4 '73	1	Gun port seals tear on first firing of gun
	T9012	LST 1181	May 31 '73	1	Gun port seals - present design lasts only approx. 8 mos.
	T9016	LST 1190	June 4 '73	1	Gun port seals - tear first time mount is fired
	T9010	LST 1188	May 31 '73	1	Gun port seals don't last - cost is excessive
	Total Category 3 Reports:			5	
	Total Ships/Stations Reporting:			5	
4		Failure or Degradation of Mechnical Linkage Mechanisms			
	T9016	LST 1190	June 4'73	1	Empty case chute door linkage
	T9012	LST 1181	May 31 '73	1	Empty case chute door linkage
	T9006	LST 1196	June 4 '73	1	Empty case chute door linkage
	Total Category 4 Reports:			3	
	Total Ships/Stations Reporting:			3	
5		Electrical Failure or Electrical Degradation of Electro-Mechanical Parts			
	Total Category 5 Reports:			0	
6		Mechanical Failure or Mechanical Degradation of Electro-Mechanical Parts			
	Total Category 6 Reports:			0	
7		Supply System Deficiency Reports or Improvement Recommendations			
	T5007	LST 1189	Feb 14 '74	1	FSN needed for end seal fwd. of recoilspring
	T4001	NOSSOFAC	Nov 13 '73	1	Gun slot covers not stocked in supply system
	T0008	LST 1195	Jul 21 '73	1	Cannibalized left gun mount (exact parts taken not reported)
	T9006	LST 1186	June 4'73	1	Increase the shear pin allowance
	Total Category 7 Reports:			4	
	Total Ships/Stations Reporting:			4	

(continued)

TABLE 2

ARINC RESEARCH CORPORATION

3"/50 GUN MOUNT MK 33 MOD 13 SUMMARY

Report Category	DCAP Report Number	Originator Ships/Station	Originator Date	Total Reports	Brief Problem Description
8	Failure or Degradation of Electricl and Electronic Circuits and Parts				
	T0033	AOR 0003	Aug 21 '73	1	Train thyrite registor burned out. (Possible faulty amplidyne field coils)
	Total Category 8 Reports:			1	
	Total Ships/Stations Reporting:			1	
9	Design Deficiency Reports or Imrpvoement Recommendations				
	T90012	LST 1181	May 31 '73		Loading machine never used. Recommend relocation elsewhere for ship's general use.
	T90012	LST 1181	May 31 '73	2	Modify weather shield to relocate windows and allow for reading elevation dials from outside. Present dial reading procedure is hazardous to personnel.
	T9016	LST 1190	June 4 '73	1	Recommend access plate in shield for servicing receiver regulator
	T9010	LST 1188	May 31 '73	1	An access plate and observation port on the shield would facilitate maintenance of the receiver regulator and the reading of elevation dials and the roller path compensator setting
	Total category 9 Reports:			4	
	Total Ships/Stations Reporting:			3	
10	Maintenance Procedures Deficiency Reports or Improvement Recommendations				
	T9010	LST 1188	May 31 '73	1	Maintaining oil level approximately one-half inch below normal in the power-off brake will eliminate the problem of power-off brake solenoid failure due to deterioration of rubber boat.
	T8505	LST 1197	Nov 9 '73	1	Revise maintenance procedures to stipulate cleaning and lubrication of gun barrel from the muzzle end.
	T8504	LST 1190	Oct 18 '73		Correction to procedures published for elevation error compensation adjustments
	T9016	LST 1190	June 4 '73	2	PMS Card A7 cannot be performed after installation of shield
	T9012	LST 1181	May 31 '73	1	Application of "Loctite" (blue) to Mk 108 panel screws holding components to prevent them vibrating loose.
	T9001	NOSL	Apr 2 '73	1	Methods of painting pipe assemblies
	T9002	NOSL	Dec 13 '73	1	Extra copies of DCAP feedback reports being provided to ships in order to assure adequate copies for ship's files and for the feedback originator personally
	T5000	LST 1195	Aug 6 '73	1	Wiring diagram for ventillation motor in OP 1753 is in error. Use NAVORD Dwg 2680840 until OP is revised.
	Total Category 10 Reports:			8	
	Total Ships/Stations Reporting:			7	
11	Support Equipment and Tools Design Deficiency Reports or Improvement Recommendations				
	Total Category 11 Reports:			0	
12	Failure or Degradation of Attaching Parts				
	T3042	LST 1196	Feb 12 '73	1	Fan blade of exhaust blower disengaged from shaft
	T3043	LST 1198	Mar 20 '73	1	Fan blade of ventilation system disengaged from shaft
	Total Category 12 Reports			2	
	Total Ships/Stations Reporting			2	
13	Personnel Training Deficiency Reports or Recommendations				
	Total Category 13 Reports:			0	
14	Failure or Degradation of Support Equipment and Tools				
	Total Category 14 Reports:			0	
	Total DCAP numbered Reports:			24	
	No. of Multiple Category Reports:			10	
	Total Generic Functional Reports:			34	

Figure 1. MARK 33 MOD 0 GUN MOUNT: DISTRIBUTION OF DCAP REPORTS BY GENERIC FUNCTIONAL CATEGORY

(Total of 59 category reports prepared between January 1973 and March 1974)

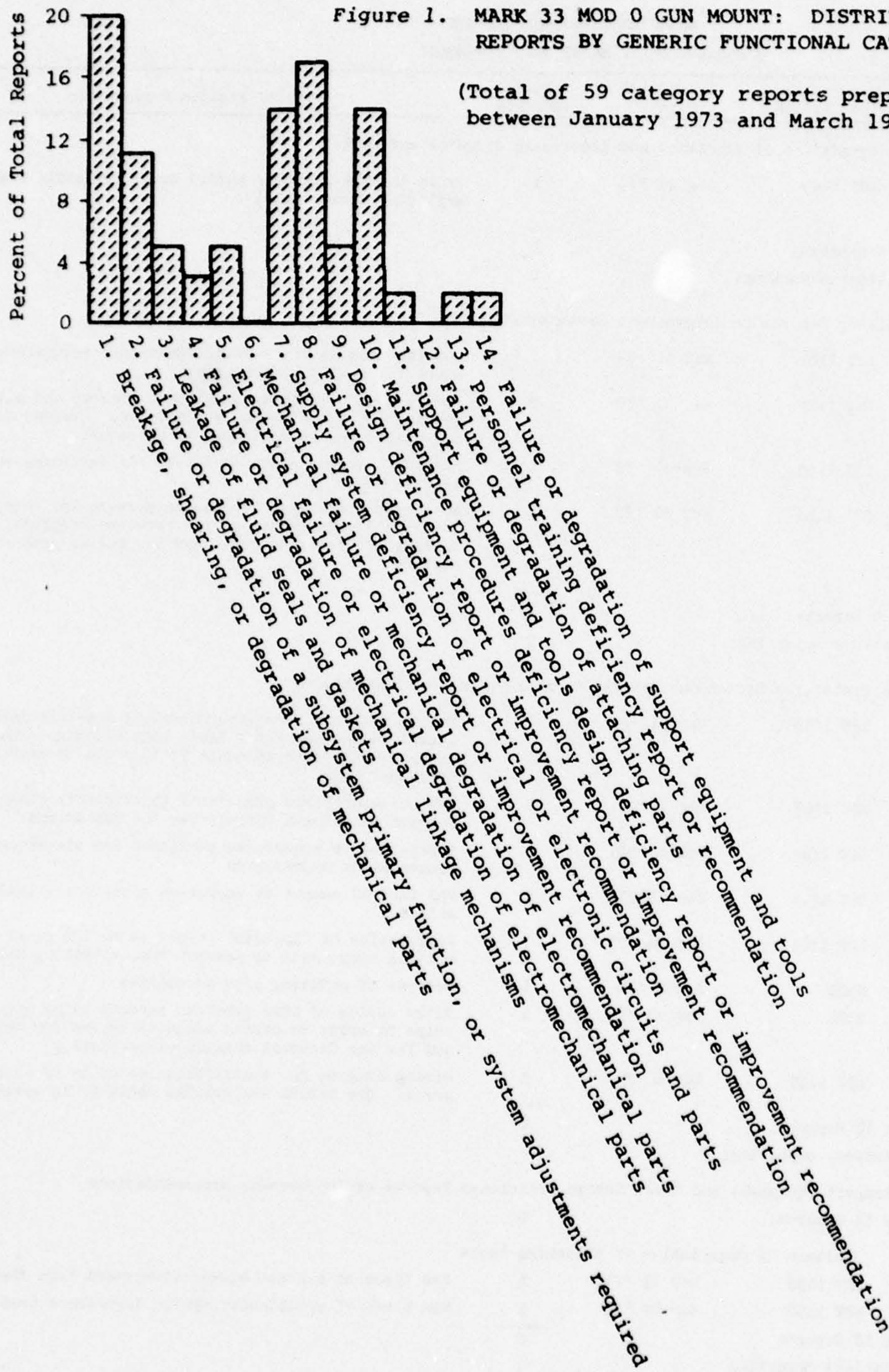


Figure 2. **MARK 33 MOD 13 GUN MOUNT: DISTRIBUTION OF DCAP REPORTS BY GENERIC FUNCTIONAL CATEGORY**

(Total of 34 category reports prepared between January 1973 and March 1974)

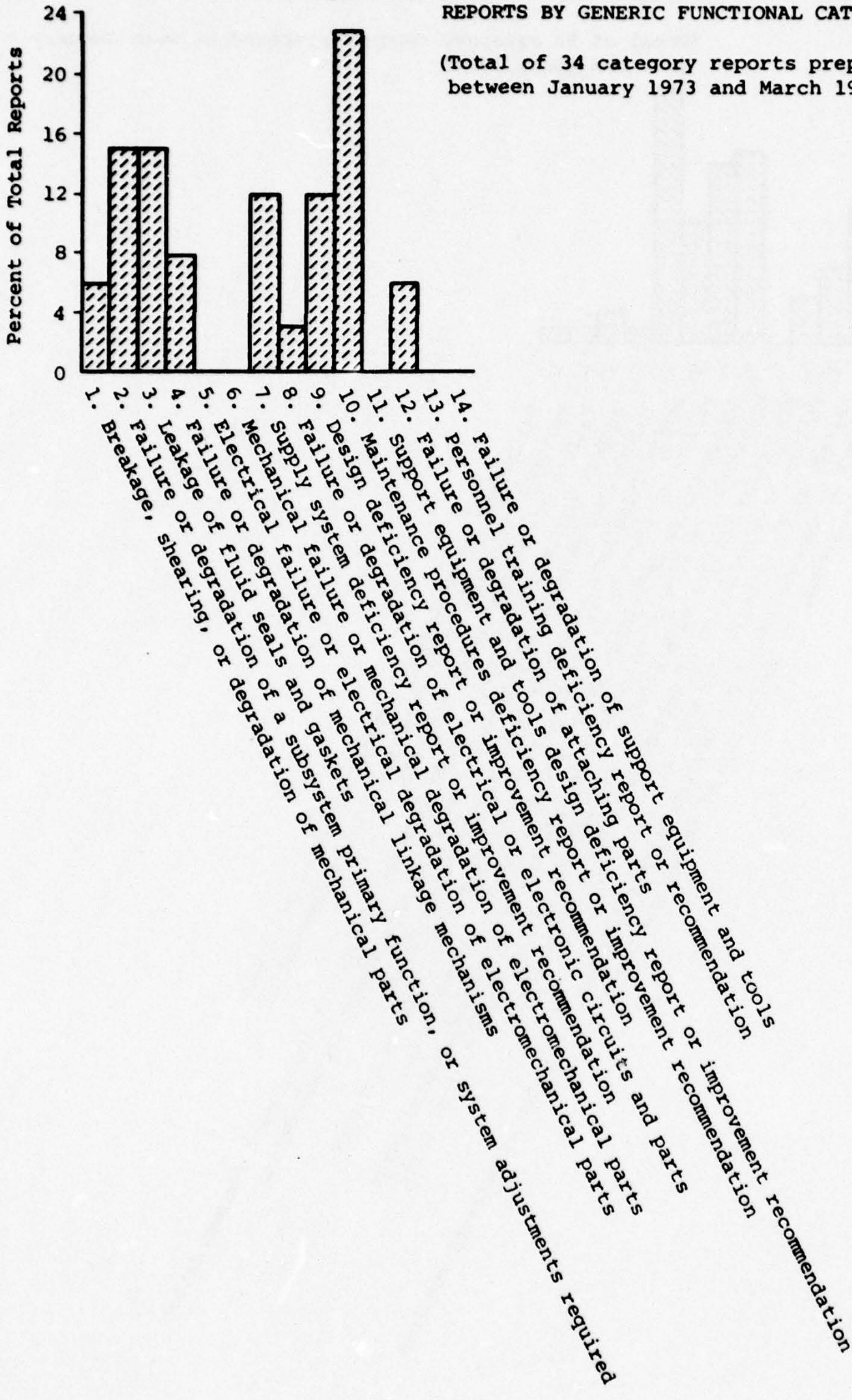
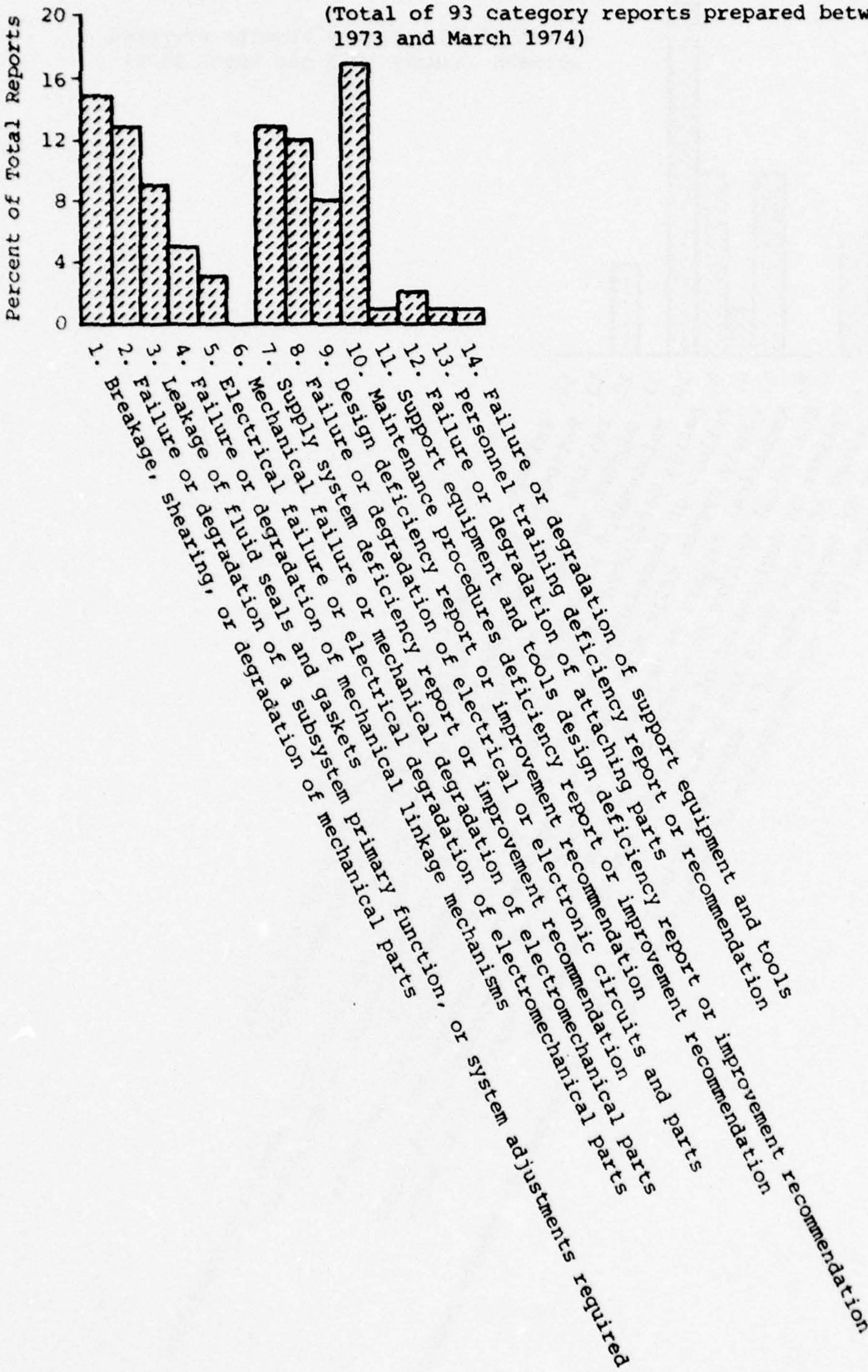


Figure 3. MARK 33 MOD 0 AND MARK 33 MOD 13 GUN MOUNTS: DISTRIBUTION OF DCAP REPORTS BY GENERIC FUNCTIONAL CATEGORY

(Total of 93 category reports prepared between January 1973 and March 1974)



APPENDIX B

RELIABILITY MODEL

(Originally submitted to NOSL Louisville 4 April 1974 by ARINC Research Corporation under Contract N00197-74-C-0267)

RELIABILITY MODEL FOR 3-INCH 50 CALIBER GUN MOUNTS

1. IDENTIFICATION OF EQUIPMENT

1.1 Gun Mount Types

The equipments included in the reliability model are the gun mounts MARK 33 MOD 0 and MARK 33 MOD 13. These are twin-mount, rapid-fire, 3-inch, 50 caliber gun mounts useful on both airborne and surface targets. The principal difference between the two gun mounts is that the MOD 13 is enclosed in a plastic shield while the MOD 0 is an open mount.

Many differences may exist among the gun mounts due to the varying configurations resulting from combinations of alternative models of guns (6), housings (2), and loaders (5 for MOD 0 and 3 for MOD 13), together with one type of slide.* One of the important configuration differences concerns the applicable loaders, MARK 2 MODs 9, 10, 11, and 12. These have a simplified, two-sprocket, shell-feed mechanism -- known as the Ferguson mechanism -- having roller gears and roller gear drive cams. Earlier MARK 2 loaders -- MODs 4, 6, and 8 -- have a more complicated three-sprocket feed mechanism, a shifting type gear train for sprocket drive, and planetary gears in the loader power drive unit.

Some of the associated gun mount equipments are not included in the model because either they are not relevant to the model under the mode of operation for which it is defined, or they are equipments that are not considered part of the gun mount as defined by the technical manuals. The systems or equipments not included in the model are: (1) Ventilating System, (2) Radar Antenna and associated wiring and wave-guide, (3) Gun Fire Control Equipment, (4) 3-Inch Sight, MARK 40 MOD 1, (5) Ring Sight, MARK 16 MOD 0, (6) Lighting System, (7) Heating System, (8) Communications System, and (9) Tompions and Canvas Covers.

1.2 Identification and Application of Loaders

The 3-Inch Loaders, MARK 2 MODs 4, 5, 6, 8, 9, 10, 11 and 12, are described in Technical Manual OP1566. MODs 4 and 5 are currently considered obsolete and are not used. The remaining MODs are installed on gun mounts generally according to the following table, although occasional variations on individual gun mounts may exist:

---

*Quantities per Technical Manual OP1566, Table 1-3, p. 1-13; however, the figures for loaders are believed to be in error. See Section 1.2 for current loader applications.

Gun Mount	3-Inch Loaders MARK 2	
	2-Sprocket MODs	3-Sprocket MODs
MK 33 MOD 0 (open)	9, 11	6
MK 33 MOD 13 (Shield)	10, 12	8

2. THE RELIABILITY BLOCK DIAGRAM

The accompanying block diagram provides a functional representation of the gun mounts. It is equally applicable to either the MARK 33 MOD 0 or the MARK 33 MOD 13, provided that, in the case of the MARK 33 MOD 0 mount, the words "and shield" be deleted from the title of Block 3 if precise representation is desired.

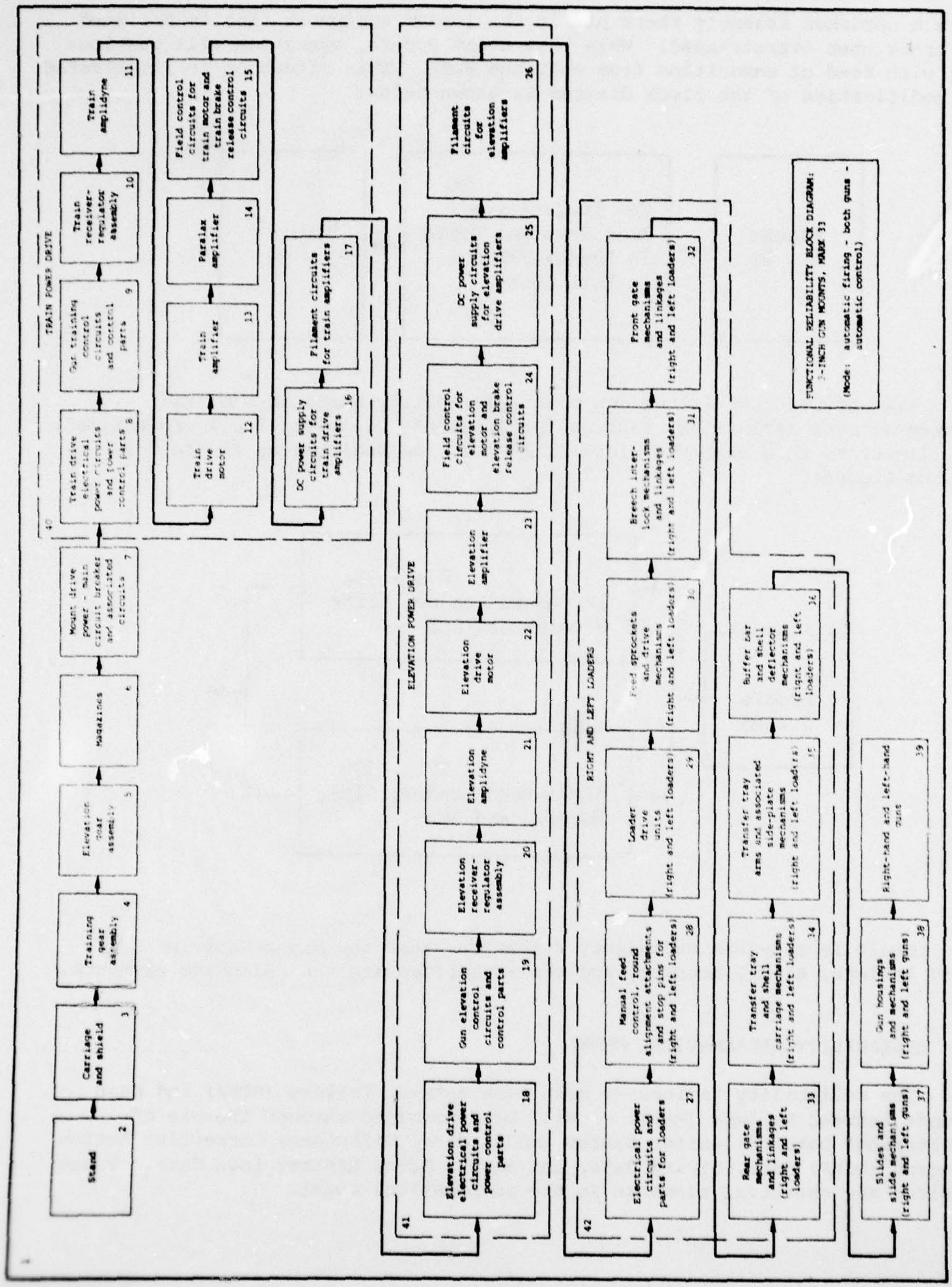
The diagram describes the gun mount system in the most important operating mode, wherein the loaders are set for automatic firing, both guns are selected, and the mount is controlled by train, elevation, and fire order control signals from an off-mount gun fire control system. The diagram is based on the definition of system success which states that both guns fire projectiles when required to do so on receiving correct train, elevation, and fire order control signals. The projectile and shell assembly is not considered to be a part of the gun mount system.

Several variations on the basic block diagram are possible, depending on interest in degradations in the operating mode and other definitions of system success. Some of these are discussed in a later section.

The paramount application of this block diagram is to define the assemblies and parts of the gun mount equipment that are associated with each system function. This definition is accomplished on the accompanying list. The list, ordered by diagram block number, contains the description, part number, Illustrated Parts Breakdown (IPB) number, and the IPB Figure and Index number for each item included under each of the blocks of the reliability diagram. All parts of the gun mounts are included, either as individual parts or, by implication, as parts of higher-order assemblies. The part numbers are arranged in two columns, one for the MOD 0 and the other for the MOD 13 equipments. In the Figure and Index columns the numbers following the slant marks are the numbers of the detailed figures; preceding numbers are the higher-order assembly and index digits.

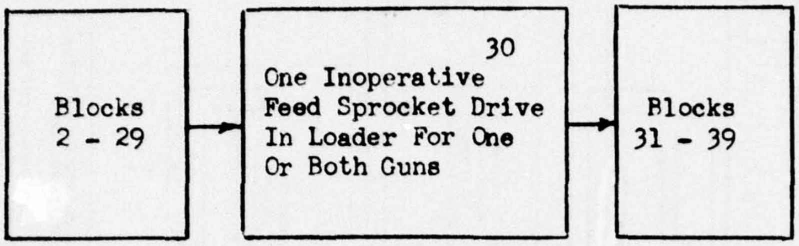
2.1 Degraded States and Other Mission Definitions:

Of particular interest is one type of failure that can cause the gun mount system to enter a degraded state. This type of failure is associated

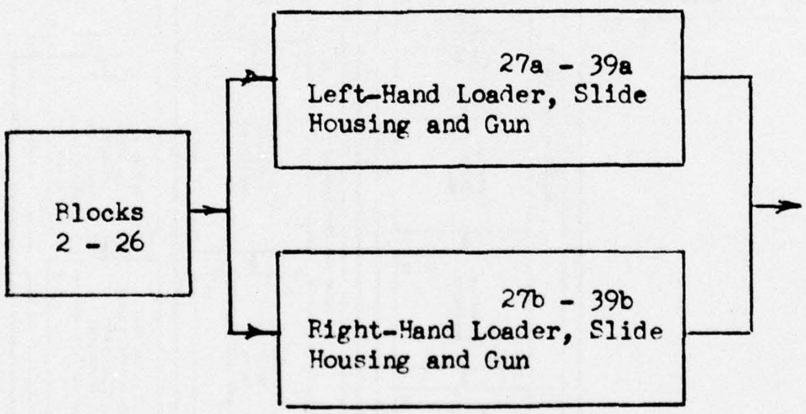


FUNCTIONAL RELIABILITY BLOCK DIAGRAM: 3-INCH GUN MOUNTS, MARK 33
(Mode: automatic firing - both guns - automatic control)
1
Stand 2
Carriage and shield 3
Training gear assembly 4
Elevation gear assembly 5
Magazines 6
Mount drive power - main circuit breaker and associated circuits 7
TRAIN POWER DRIVE
40
Train drive electrical power circuits and power control parts 8
Gun training control circuits and control parts 9
Train receiver-regulator assembly 10
Train amplidyne 11
Train drive motor 12
Train amplifier 13
Parallax amplifier 14
Field control circuits for train motor and train brake release control circuits 15
DC power supply circuits for train drive amplifiers 16
Filament circuits for train amplifiers 17
ELEVATION POWER DRIVE
41
Elevation drive electrical power circuits and power control parts 18
Gun elevation control circuits and control parts 19
Elevation receiver-regulator assembly 20
Elevation amplidyne 21
Elevation drive motor 22
Elevation amplifier 23
Field control circuits for elevation motor and elevation brake release control circuits 24
DC power supply circuits for elevation drive amplifiers 25
Filament circuits for elevation amplifiers 26
RIGHT AND LEFT LOADERS
42
Electrical power circuits and parts for loaders 27
Manual feed control, round alignment attachments and stop pins for (right and left loaders) 28
Loader drive units (right and left loaders) 29
Feed sprockets and drive mechanisms (right and left loaders) 30
Breech inter-lock mechanisms and linkages (right and left loaders) 31
Front gate mechanisms and linkages (right and left loaders) 32
Rear gate mechanisms and linkages (right and left loaders) 33
Transfer tray and shell carriage mechanisms (right and left loaders) 34
Transfer tray arms and associated side-plate mechanisms (right and left loaders) 35
Buffer bar and shell deflector mechanisms (right and left loaders) 36
Slides and slide mechanisms (right and left guns) 37
Gun housings and mechanisms (right and left guns) 38
Right-hand and left-hand guns 39

with a sprocket assembly shear pin in the loader equipment that is designed to break when overstressed. When this event occurs, operation will continue but with feed of ammunition from only one side. This situation is illustrated by modification of the block diagram as shown below:



Also of interest is the gun mount reliability based on a minimal system-success definition, such as "at least one gun must fire a projectile". To illustrate this case the block diagram may be modified as in the following figure:



The result is a system redundancy situation where the Right-Hand and Left-Hand loaders, slide, housing, and gun assemblies are the redundant elements.

3. RELIABILITY MATHEMATICAL MODEL

The reliability indices -- Mean Time Between Failure (MTBF) and Mean Rounds Between Failure (MRBF) -- will be determined through the use of Maintenance Data Collection System (MDCS) data, Deficiency Corrective Action Program (DCAP) data, firing data, and ships' Mount History Logs data. These indices are essential elements in the mathematical model.

To develop a system reliability function that will be useful in estimating system reliability for various mission time periods, one essential is a definition of the mission.

3.1 3-Inch 50 Caliber Gun Mounts - Mission Definition

For the gun mounts discussed in this report, the mission can be defined in terms of two mission segments that reflect the demands for operation of the various subassemblies of the system. The first segment is a ready period when the gun mounts are being trained and elevated (or may be at rest with power on) while the guns and loaders are ready but not in motion. During Segment 2, when the guns are actually firing, all subsystems are operating. The degree of stress placed on the train and elevation mechanisms and power drives is subject to random variation, depending on the demands as indicated by the control signals from the gun fire control system; however, we assume that this variation will average out given a sufficiently large data base for the computation of the reliability indices. The figure below defines the gun mount mission period segments for any given total mission time, t_M:

3-INCH 50 CALIBER GUN MOUNTS - MISSION DEFINITION

t_0 — t_1 — Time — t_2 — t_M

SEGMENT 1	SEGMENT 2	REPEAT SEGMENTS
Ready Period: Guns & Loaders on Active Stand-by Train & Elevation Drives Operating at Various Power Levels	Firing Period: Entire System Operating	Repeat Segments 1 & 2 Alternately to Define Complete Mission Time Ending With Power Off.

The time period for Segment 1 can be determined from clock readings, or from elapsed-time meter readings when these are available on the systems. The time period for Segment 2 can be obtained from readings of the rounds-fired counter, combined with the rate of fire. The mission reliability of the system is the probability that the system will perform satisfactorily

for at least the period of time from t_0 to t_M when used under stated conditions. It will be necessary to establish, from observation of the data, elapsed times for Segments 1 and 2 that are representative of the normal use of the gun mounts.

3.2 Reliability Equations

3.2.1 General Reliability Equation

The reliability block diagram shows that a series relationship exists between the functional blocks of the system. Therefore, failure of any one of the functions constitutes failure of the system. In this case the system reliability is obtained by forming the product of the individual block reliabilities. This process is expressed by the following general equation:

$$R_1 (t) = R_2 (t) \cdot R_3 (t) \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot R_{39} (t) \qquad (1)$$

The general equation, Equation 1, recognizes that distributions of failures with respect to time may not be the same for all of the functions. Some of the functions may have normal, or Gaussian, distributions and others may have distributions such as those of the exponential or gamma types. Therefore, although the MTBF and MRBF indices may be obtainable from available data, Equation 1 could not be used to compute accurately the overall system reliability unless the data were sufficient to establish the type of failure distribution which is applicable to each functional block.

At the *overall system level,* however, reliability analysis experience has provided us with an alternative to the lengthy procedure described above. The experience indicates that systems having large numbers of parts which have different failure distributions do tend to have system-level time-to-failure densities closely approximated by exponential expressions. Thus, it may be found that while uneconomical quantities of data would be needed for accurately determining the individual function failure densities, the overall system reliability can be determined from a relatively simple expression, specifically:

$$R_1 (t) = \exp. (-t/\Theta) \qquad (2)$$

where

t = time

$\Theta = 1/\lambda$ = MTBF

λ = failure rate (failure per unit time)

MTBF = Total System Operate Time/Total System Failures

3.2 Degraded State Equations

The first degraded state illustrated in Section 2.1 -- where one feed sprocket drive of a loader becomes inoperative -- can be adequately handled for reliability computation through a change in the mission success definition and application of reliability equations for parallel redundancy. If mission success is defined as "at least one feed sprocket operates satisfactorily", and since breakage of the shear pin assures that failure of one sprocket mechanism does not influence the operation of the other, the following equation applies:

$$R_{30}(t) = 1 - [1 - R_s(t)]^2 \tag{3}$$

where

$R_{30}(t)$ = the reliability function of Block 30

$R_s(t)$ = the reliability function of either sprocket drive assembly (both are identical)

The same parallel redundancy equation can be utilized in computation of reliability for the other previously mentioned degraded state. If success for this portion of the system is defined as "at least one gun must fire a projectile", then, in accordance with the parallel redundancy diagram of Section 2.1 -- showing two identical parallel elements, neither of which influences the other on failure -- the Equation 3 subscripts can be modified to fit this case as follows:

$$R_{27-39}(t) = 1 - [1 - R_g(t)]^2 \tag{4}$$

where

$R_{27-39}(t)$ = the reliability function of blocks 27 to 29 combined

$R_g(t)$ = the reliability function of either the left-hand or the right-hand loader, slide, housing, and gun barrel (both assemblies are identical)

4. RELIABILITY MODEL FLEXIBILITY

The reliability model may be expanded to cover any areas discovered during system tests which are of special interest.

IDENTIFICATION OF EQUIPMENT ITEMS BY ASSOCIATION WITH BLOCKS OF THE RELIABILITY BLOCK DIAGRAM FOR 3-INCH GUN MOUNTS MARK 33

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
1	3 - INCH 50-CALIBER TWIN MOUNT MARK 33 MOD 0	513982	2813480	OP1753	1 -
2	3 - INCH STAND ASSEMBLY MARK 22 MOD 1	511151	1691963		1-16/73
3	3 - INCH CARRIAGE ASSY MK 22 MOD 3	511153			1-15/53
	3 - INCH CARRIAGE ASSY MK 22 MOD 12		2813483		1-19/67
	3 - INCH SHIELD ASSY MK 19 MOD 1		2813486		1-2/14
4	3 - INCH TRAINING GEAR ASSY:				
	MK 2 MOD 1	510734			1-13/41
	MK 2 MOD 2		1691964		1-13/41
5	3 - INCH ELEVATION GEAR ASSY:				
	MK 4 MOD 1	514655			1-10/34
	MK 4 MOD2		169177		1-10/34
6	3 - INCH MAGAZINE ASSY :				
	Rh, Mk 2 MOD 1	513903-2			1-11/40
	Lh, MK 2 MOD 2	513903-1			1-11/40
	(LD167541): MK 1 MOD 0	508404	508404		1-12/38
	(LD167542): MK 1 MOD 1	508405	508405		1-12/38
	(LD167543): Mk 1 MOD 2	508404	508404		1-12/38
	(LD167544); MK 1 MOD 3	508405	508405		1-12/38
	MK 1 MOD 4		1814096		1-12/39
	MK 1 MOD 5		1814098		1-12/39
7	Parts of Control Panel Assembly:				
	MK 65 MOD 0:				
	Operating Mechanism Assembly	480804-18			92-
	Air Circuit Breaker, SP	480804-17			92-8
	Timing Relay, TR-3	480804-5			92-13
	Field Supply Control Relay, CR-4	480804-7			92-15
	Overload Relays, OL-1 & OL-2	480804-8			92-30
	Overload Relays, OL-3 & OL-4	480804			92-35
	Reset Relays, RR-1 & RR-2	480804-10			92-32
	Reset Relays, RR-3 & RR-4	480804-15			92-38
	Control Circuit & Filament Transformer, T-1	480804-20			92-40
	Plate Supply Transformer, T-2	480804-21			92-41
	Fuse Clip Assembly	480804-24			92-42
	Fuses (3) 10 A.	480804-25			92-43
	Capacitor, 1 MFD, 1 KV, C-1 & C-2	480804-27			92-45

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
7	(Continued) Parts of Control Panel Assembly, MK 65 MOD 0:				
	Resistor, 470 Kohms, R-1 & R-2	480804-28		OP1753	92-46
	Power Drive Brake Control Relay, CR-5	480804-7			92-15
	Parts of Control Panel Assembly: MK 108 MOD 0:				
	Lever Assembly	501291-39	501291-39		93-
	Circuit Breaker	501291-8	501291-8		93-13
	Control & Filament Transformer, T-1	980657-2	980657-2		93-37
	Plate Supply Transformer, T-2	980657-1	980657-1		93-38
	Capacitor, C-1 & C-2	980657-4	980657-4		93-41
	Brake Control Relay, CR-5	501291-18	501291-18		93-45
	Plate Supply Control Relay, CR-4	501291-17	501291-17		93-46
	Resistor, R-1 & R-2 (RC30AF474K)	501291-36	501291-36		93-53
	Fuseblock & Bracket Assy	501291-96	501291-96		93-63
	Fuses (3) 10A	501291-23	501291-23		93-64
	Overload Relays, OL-11 & OL-21	501291-10	501291-10		93-29
	Overload Relays, OL-12 & OL-22	501291-11	501291-11		93-30
	Overload Relay, OL-32	501291-12	501291-12		93-31
	Overload Relay, OL-31	501291-13	501291-13		93-32
	Brake Interlock Relay, CR-6	501291-14	501291-14		93-44
	Parts of Control Panel Assembly: MK 237 MOD 0:				
	Lever Assembly	501291-39	501291-39		94-
	Circuity Breaker	501291-8	501291-8		94-13
	Overload & Reset Assy., OL-1/RR-1 & OL-2/RR-2	1676564	1676564		94-29
	Overload & Reset Assy., OL-3/RR-3	1676565-1	1676565-1		94-32
	Overload & Reset Assy., OL-4/RR-4	1676565-2	1676565-2		94-33
	Control and Filament Transformer, T-1	980657-2	980657-2		94-50
	Plate Supply Transformer, T-2	980657-1	980657-1		94-51
	Capacitor, 1 MFD. 1 KV, C-1 & C-2	980657-4	980657-4		94-52
	Resistor (RC30AF474K), R-1 & R-2	501291-36	501291-36		94-53
	Fuseblock & Bracket Assy.	501291-96	501291-96		94-56
	Fuses (3) 10A	501291-23	501291-23		94-57
	Field Supply Relay, CR-4	597431	597431		94-65
	Power Dirve Brake Control Relay, CR-5	1676536	1676536		94-66

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
7	(Continued)				
	Parts of Control Panel MK 62 MOD 0:				
	START, STOP & EMERGENCY-RUN Push -button Assys.	17-S-57433-2539	17-S-57433-2539	OP1753	87-102
	Parts of One-man Control Stations:				
	Safety Switches of left-hand handle of one-man control assemblies (Alternate):	319211-11 402493-5	319211-11 402493-5		90-13
	Part of Control Panel, MK 60, MOD 1:				
	Emergency Stop Push-button Assembly	697603-21	697603-21	CP1566	41-35
	Conductors, cables and terminals associated with the Block 7 parts, above , and including:				
	MISCELLANEOUS ELECTRICAL EQUIPMENT (Armored Cable)	LD168593	LD168593	OP1753	1-17
	MISCELLANEOUS ELECTRICAL EQUIPMENT (Unarmored Cable)	LD411071	LD411071	OP1753	1-18

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
8	Parts of Control Panel Assy. MK 65 MOD 0 :				
	Paralax Synchro Power Relay, TR-1	480804-5		OP1753	92-13
	Train Line Contactor, 1M	480804-4			92-11
	Paralax Synchro Power Control Relay, CR-3	480804-7			92-15
	Train Synchro Power Control Relay, CR-2	480804-7			92-15
	Auxilliary Relay, R	480804-6			92-14
	Part of Motor Field Control Assy., 688774:				
	Train Field Circuit Relay, K-302	688999-3			99-12
	Parts of Control Panel Assy., MK 108 MOD 0 :				
	Train Amplidyne Motor Power Line Contactor, LC-1	501291-3	501291-3		93-58
	Paralax Synchro Power Timing Relay, TR-1	501291-19	501291-19		93-54
	Train Synchro Power Control Relay, CR-2	501291-15	501291-15		93-48
	Part of Motor Field Control Assy., 688774:				
	Train Field Circuit Relay, K-302	688999-3	688999-3		99-12
	Part of Control Panel Assy., MK 108 Mod 0 :				
	Isolation Transformer, T-3	980657-5	980657-5		93-70
	Parts of Control Panel Assy., MK 237 MOD 0 :				
	Train Amplidyne Motor Power Line Contactor, LC-1	1340707	1340707		94-36
	Paralax Synchro Power Timing Relay, TR-1	1676557	1676557		94-69
	Paralax Synchro Power Control Relay, CR-3	1676534	1676534		94-64
	Train Synchro Power Control Relay, CR-2	1676534	1676534		94-64
	Line Contactor Holding Relay, CR-6 (Relay MK 9 MOD 0)	628242	628242		94-46
	Isolation Transformer, T-3	980657-5	980657-5		94-63
	Part of Motor Field Control Assy., 688774:				
	Train Field Circuit Relay, K-302	688999-3	688999-3		99-12

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
9	The parts pertaining to train control in the following assemblies:				
	Control Panel (Local Surface Operator) (except power control parts under block 7) Mk 62 MOD 0	688932	688932	OP1753	87-
	One Man Control (except power control parts under Block 7) MK 2 MOD 0	636227	636227	OP1753	88-
	Firing Cut-out Indicator Panel:				
	Indicator Assy.	513700-2	513700-2	OP1566	40-
	Illumination Shield	764163	764163	OP1566	40-
	Right and Left Fire Cut-out Indicator Lights and associated parts of Control Panel MK 60 MOD 1	512065	512065	OP1566	41-

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPP Number	Figure Index
10	TRAIN RECEIVER-REGULATOR ASSY.				
	MK 29 MOD 22	1311858		OP1753	2-1/75
	MK 29 MOD 23	1473019	1473019		2-1/75
11	MOTOR GENERATOR SET (AMPLIDYNE)				
	MK 6 MOD 0	589175-1			2-10/104
	MK 6 MOD 1	664089-1	664089-1		2-10/104
12	TRAIN DRIVE MOTOR ASSY.				
	MK 1 MOD 0	589169-1	589169-1		2-5/91
13	TRAIN AMPLIFIER ASSY.	1311870			97-26/101
	TRAIN AMPLIFIER ASSY.	1473028	1473028		97-27/101
14	PARALLAX AMPLIFIER ASSY	688773	688773		97-25/100
15	MOTOR FIELD CONTROL ASSY. LD294566	688774	688774		97-24/99
16	POWER SUPPLY ASSY. LD294564	688764	688764		97-30/102
17	Filament Transformers, Vacuum Tube Heaters and associated circuit parts in the various units of Amplifier Assembly MK 40 MOD 2 and MK 40 MOD 3				
		1311875			97-
		1473027	1473027		97-

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
18	Parts of Control Panel, MK 65 MOD 0:				
	Elevation Timing Relay, TR-2	480804-5		OP1753	92-13
	Elevation Line Contactor, 2M	480804-4			92-11
	Elevation Synchro Power Control Relay, CR-1	480804-7			92-15
	Part of Motor Field Control Assy., 688774 :				
	Elevation Field Circuit Relay, K-301	688999-3			99-12
	Parts of Control Panel, MK 108 MOD 0:				
	Elevation Amplidyne Motor Power Contactor, LC-2	501291-4	501291-4		93-59
	Elevation Synchro Power Control Relay, CR-1	501291-14	501291-14		93-44
	Part of Motor Field Control Assy., 688774 ;				
	Elevation Field Circuit Relay, K-301	688999-3	688999-3		99-12
	Parts of Control Panel, MK 237 MOD 0:				
	Elevation Timing Relay, TR-2	1676557	1676557		94-69
	Elevation Amplidyne Motor Power Contactor, LC-2	1340707	1340707		94-36
	Elevation Synchro Power Control Relay, CR-1	1676534	1676534		94-64
	Part of Motor Field Control Assy., 688774:				
	Elevation Field Circuit Relay, K-301	688999-3	688999-3		99-12

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
19	Parts pertaining to elevation control in the following assemblies:				
	Control Panel (Local Surface Operator) (except power control parts under Plock 7) MK 62 MOD 0	688932	688932	OP1753	87-
	One-Man Control (except power control parts under Block 7) MK 2 MOD 0	636227	636227	OP1753	88-

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
20	ELEVATION RECEIVER-REGULATOR ASSY.	1473023	1473023	OP1753	2-2/81
21	MOTOR GENERATOR SET (AMPLIDYNE)				
	MK 6 MOD 0		589175-1		2-10/104
	MK 6 MOD 1	664089-1	664089-1		2-10/104
22	ELEVATION DRIVE MOTOR ASSY.				
	MK 1 MOD 0	589169-1	589169-1		2-6/91
23	ELEVATION AMPLIFIER ASSY.	1311871			97-28
			1473030		97-29
24	MOTOR FIELD CONTROL ASSY.	688774	688774		97-24
25	POWER SUPPLY ASSEMBLY	688764	688764		97-30
26	Filament Transformers, Vacuum Tube Heaters and associated circuit parts in the various units of Amplifier Assembly MK 40 MOD 2 :	1311875			97-
	and MK 40 MOD 3 :	1473027	1473027		

AD-A054 498 ARINC RESEARCH CORP ANNAPOLIS MD F/G 19/6
A RELIABILITY - MAINTAINABILITY - AVAILABILITY ASSESSMENT OF 3---ETC(U)
JAN 75 F E ERDLE N00197-74-C-0267
UNCLASSIFIED 1622-02/03-1-1345 NL

2 OF 2
AD
A054498

END
DATE
FILMED
6-78
DDC

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
27	Parts of following assemblies pertaining to loader power and control:				
	Control Panel (Gun Captain's) MK 60 MOD 1	512065	512065	OP1566	41-
	Indicator Panel Assy. MK 1 MOD 1	512012	512012		39-
	Loader Control System Assy.	512066			1-27/33
		1466447	1466447		1-29/33
		1466452	1466452		1-30/33
	Miscellaneous Electrical Equipment	513770			1-34/38
		1445660	1445660		1-36/38

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
28	The following parts of Feed Mechanism Assy. 511920 or Feed Mechanism Assy. 1466438:				
	Taper Pin	511961-12	511961-12	OP1566	6-24
	Retaining Bushing	511961-8	511961-8		6-25
	Retaining Bushing	511961-9	511961-9		6-26
	Switch Actuator, RH	1260317	1260317		6-27
	Switch Actuator, LH	1260318	1260318		6-28
	Shaft Return Spring	511961-3	511961-3		6-29
	Shaft Return Spring	511961-4	511961-4		6-30
	Lubrication Fitting	MS15004-2	MS15004-2		6-31
	Rear Actuating Arm, RH	511964-2	511964-2		6-32
	Rear Actuating Arm, LH	511964-3	511964-3		6-33
	Lubrication Fitting	MS15004-3	MS15004-3		6-34
	Forward Actuating Arm, LH	511963-2	511963-2		6-35
	Forward Actuating Arm, RH	511963-3	511963-3		6-36
	Rear Lever, RH	511962-6	511962-6		6-37
	Rear Lever, LH	511962-7	511962-7		6-38
	Front Lever, RH	511962-5	511962-5		6-40
	Front Lever, LH	511962-4	511962-4		6-39
	Woodruff Key	MS35756-6	MS35756-6		6-41
	Actuating Arm Return Spring	511961-5	511961-5		6-42
	Actuating Arm Return Spring	511961-6	511961-6		6-43
	Shaft Collar	511961-10	511961-10		6-44
	Taper Pin	511961-12	511961-12		6-45
	Aligning Shaft	511692-1	511692-1		6-46
29	LOADER DRIVE ASSEMBLY	511929			1-11/9
		1466415	1466415		1-14/9
		1583790	1583790		1-15/9
			1466424		1-13/9
30	FEED MECHANISM ASSEMBLY (Except parts listed under Block 28, above)	511920	511920		6-
		1466438	1466438		6-
	FRONT FRAME ASSEMBLY	511919	511919		7-
		1479884	1479884		8-
		1583795	1583795		8-
31	BREECH INTERLOCK ASSEMBLY	512439	512439		1-24/28
32	GATE OPERATING MECHANISM ASSY.	513916	513916		1-22/23
33	REAR FRAME ASSEMBLY	511918	511918		5-
		1466409	1466409		5-
		1583787	1583787		5-
34	TRAY AND SHELL CARRIAGE ASSY.	512438	512438		1-16/17
35	RIGHT SIDE PLATE AND LOWER BUFFER ASSEMBLY (except LOWER BUFFER ASSY. 511916-3)	513910	513910		1-19/21

Diagram Block Number	Description of Item	Part Number MOD 0	Part Number MOD 13	IPB Number	Figure Index
35	(Continued);				
	LEFT SIDE PLATE AND SWITCH ASSY.	513986	513986	OF1566	1-26/30
36	LOWER BUFFER ASSEMBLY	511916-3	511916-3		21-5
	BUFFER BAR AND SHELL DEFLECTOR ASSEMBLY	512424	512424		1-17/20
37	3-INCH SLIDE ASSY.,RH MK27 MOD 0	512480	512480		43-
	3-INCH SLIDE ASSY.,LH MK27 MOD 1	512481	512481		43-
38	3-INCH HOUSING ASSY., MK 8 MOD 2	660817	660817		49-
	3-INCH HOUSING ASSY., MK 8 MOD 3	1357425	1357425		49-
39	3-INCH GUN BARREL ASSY., MK 22:				
	MOD 4	507082	507082		57-
	MOD 5	507083	507083		57-
	MOD 6	660830	660830		57-
	MOD 7	660831	660831		57
	MOD 8	516709	516709		57-
	MOD 9	516719	516719		57-

APPENDIX C

LIST OF SHIPS CONTRIBUTING INFORMATION FOR OPERATE TIME AND ROUNDS-CYCLED ESTIMATES

Name	Type/Hull No.	Data Period
Atlantic Fleet Ships:		
Charleston	LKA 113	February 17, 1971 to May 30, 1974
Raleigh	LPD 1	April 30, 1971 to November 19, 1973
Austin	LPD 4	April 14, 1971 to May 14, 1974
Plymouth Rock	LSD 29	January 22, 1971 to April 24, 1972
Hermitage	LSD 34	January 9, 1971 to January 10, 1973 and July 25, 1973 to May 1, 1974
Portland	LSD 37	January 15, 1971 to July 31, 1971 and August 1, 1972 to October 18, 1973 and January 1, 1974 to February 25, 1974
Pensacola	LSD 38	August 1, 1972 to March 4, 1974
Manitowoc	LST 1180	January 17, 1973 to May 30, 1974
LaMoure County	LST 1194	February 5, 1972 to February 16, 1974
Harlan County	LST 1196	June 8, 1972 to May 31, 1974
Pacific Fleet Ships:		
Durham	LKA 114	July 30, 1969 to July 27, 1971 and August 8, 1972 to June 30, 1974
Vancouver	LPD 2	March 3, 1971 to April 29, 1974
Denver	LPD 9	May 19, 1971 to July 12, 1974

APPENDIX D

SHIPS WITH FAVORABLE RATIOS OF REPORTED MAINTENANCE EVENTS TO TOTAL MAINTENANCE EVENTS

LIST OF SHIPS WHOSE RATIO OF MAINTENANCE EVENTS REPORTED ON 4790/2K FORMS TO TOTAL EVENTS WAS .80 OR GREATER DURING BOTH YEARS 1972 AND 1973* (MARK 33 MOD O 3-INCH 50 CALIBER GUN MOUNTS)

Hull No.	Ratio in 1972	Ratio in 1973
AF 0059	.89	1.00
LSD 0028	.94	.83
LSD 0033	.93	.83
AS 0032	.95	1.00
AS 0033	1.00	1.00
AFS 0003	1.00	1.00
AFS 0004	1.00	1.00
AFS 0006	1.00	1.00
AFS 0007	1.00	1.00
AE 0027	1.00	.86
AO 0144	.90	.94
AO 0146	1.00	.90
AO 0148	.93	.90
LDP 0004	.88	.84
LPD 0007	.96	.91
LPH 0003	.82	1.00
DLG 0020	.89	.88
DLG 0024	.88	.87
TOTAL SHIPS REPORTING: 1972: 115; 1973: 109		

*Derived from "MDCS Corrective Maintenance Summary" reports prepared by OMMIC, WPNSTA, Concord, California.

LIST OF SHIPS WHOSE RATIO OF MAINTENANCE EVENTS REPORTED ON 4790/2K FORMS TO TOTAL MAINTENANCE EVENTS WAS .80 OR GREATER IN BOTH YEARS 1972 AND 1973* (MARK 33 MOD 13 3-INCH 50 CALIBER GUN MOUNTS)

Hull No.	Ratio in 1972	Ratio in 1973
AOE 0003	1.00	.95
DE 1023	1.00	1.00
LPH 0011	1.00	1.00
LSD 0036	1.00	.86
LST 1180	.92	.97
LST 1189	.86	1.00
LST 1191	.92	.95
LST 1195	.93	.83
LST 1198	1.00	1.00
TOTAL SHIPS REPORTING: 1972: 63; 1973: 63		

*Derived from "MDCS Corrective Maintenance Summary" reports prepared by OMMIC, WPNSTA, Concord, California.

APPENDIX E

DATA SUMMARIES AND OPERATIONAL AVERAGES MARK 33 MOD 0 AND MOD 13 GUN MOUNTS

TABLE E-1

DATA SUMMARY AND OPERATIONAL AVERAGES

3 INCH 50 CALIBER MARK 33 MOD 0 GUN MOUNT

1. Data Summary:

1.1	Total of ships in data collection sample	10
1.2	Total of ship sample censored	3
1.3	Total of ship samples for analysis	7
1.4	Total of gun mounts in data sample analyzed	20
1.5	Total gun mount calendar-months in data sample analyzed (Approx.)	675
1.6	Data period range (over all ships): 1/1/71 to 6/30/74	
1.7	Total gun alert exercises in data sample analyzed	651
1.8	Total gun firing exercises in data sample analyzed	249
1.9	Total rounds fired during exercises (from gunnery logs)	10,357
1.10	Total estimated rounds cycled warm-up for exercises and during PMS periods	36,188
1.11	Total estimated rounds cycled in data sample analyzed	46,545
1.12	Total estimated operate hours during gun alert exercises (estimated from records in Quartermasters log books)	3,941.24
1.13	Total estimated operate hours during warm-up for exercises and during PMS periods	7,213.56
1.14	Total estimated operate hours	11,154.80

2. Operational Averages Per Gun Mount:

2.1	Rounds fired per firing exercise (10,357/249X20)	2.1
2.2	Estimated rounds cycled per estimated operate hour (46,545/11,154.8)	4.2
2.3	Estimated rounds cycled per calendar-month (46,545/675)	69
2.4	Estimated rounds cycled per calendar-month during warm-up for exercises and during PMS (36,188/675)	54
2.5	Average operate hours/gun mount/month:	16.5256

TABLE E-2

DATA SUMMARY AND OPERATIONAL AVERAGES

3 INCH 50 CALIBER MARK 33 MOD 13 GUN MOUNT

1. Data Summary:

1.1	Total of ships in data collection sample	7
1.2	Total of ship sample censored	1
1.3	Total of ship samples for analysis	6
1.4	Total of gun mounts in data sample analyzed	12
1.5	Total gun mount calendar-months in data sample analyzed (Approx.)	357
1.6	Data period range (over all ships): Jan. 1, 1971 to June 30, 1974	
1.7	Total gun alert exercises in data sample analyzed	552
1.8	Total gun firing exercises in data sample analyzed	193
1.9	Total rounds fired during exercises (from gunnery logs)	8,165
1.10	Total estimated rounds cycled warm-up for exercises and during PMS periods	15,637
1.11	Total estimated rounds cycled in data sample analyzed	23,802
1.12	Total estimated operate hours during gun alert exercises (estimated from records in Quartermasters log books)	2,219.10
1.13	Total estimated operate hours during warm-up for exercises and during PMS periods	4,451.76
1.14	Total estimated operate hours	6,670.86

2. Operational Averages Per Gun Mount:

2.1	Rounds fired per firing exercise (8165/(193 x 12)	3.5
2.2	Estimated rounds cycled per estimated operate hour (23,802/6,670.86)	3.6
2.3	Estimated rounds cycled per month (23,802/357)	66.7
2.4	Estimated rounds cycled per month during warm-up for exercises and during PMS (15,673/357)	43.9
2.5	Average operate hours/gun mount/month:	18.6859

APPENDIX F

RELIABILITY INDICES FOR THE MOD 0 GUN MOUNT MAJOR COMPONENTS

TABLE F-1

MEAN TIME BETWEEN ACTIONS AND ACTION RATE FOR MAJOR COMPONENTS OF GUN MOUNT (Less: Loaders, Slides, Housings, and Gun Barrels) 3 INCH 50 CALIBER MARK 33 MOD 0 GUN MOUNT (For all maintenance actions)

Reliability Diagram No.	Component Name	No. of Actions	Actions Per (10,000Hr.)	MTBA (Hrs.)
1	Gun Mount	4	N.A.	N.A.
2	Stand	0	0	N.A.
3*	Carriage and shield	16	14.3	697
4*	Training gear assembly	10	8.96	1,115
5*	Elevation gear assembly	19	17.0	587
6	Magazines	1	.896	11,155
7	Mount drive power - main circuit breaker and associated circuits	6	5.38	1,859
8	Train drive electrical power circuits and power control parts	2	1.79	5,577
9*	Gun training control circuits and control parts	18	16.1	620
10	Train receiver-regulator assembly	2	1.79	5,577
11	Train amplidyne	3	2.69	3,718
12	Train drive motor	1	.896	11,155
13*	Train amplifier	33	29.6	338
14*	Parallax amplifier	32	28.7	349
15*	Field control circuits for train motor and train brake release control circuits	26	23.3	429
16*	DC power supply circuits for train drive amplifiers	20	17.9	558
17	Filament circuits for train amplifiers	0	0	N.A.
18	Elevation drive electrical power circuits and power control parts	0	0	N.A.
19	Gun elevation control circuits and control parts	8	7.17	1,394
20	Elevation receiver-regulator assembly	3	2.69	3,718
21	Elevation amplidyne	1	.896	11,155
22	Elevation drive motor	1	.896	11,155

TABLE F-1 (continued)

Reliability Diagram No.	Component Name	No. of Actions	Actions (10,000Hr.)	MTBA (Hrs.)
23*	Elevation amplifier	21	18.8	531
24*	Field control circuits for elevation motor and elevation brake release control circuits	12	10.8	930
25*	DC power supply circuits for elevation drive amplifiers	17	15.2	656
26	Filiament circuits for elevation amplifiers	0	0	N.A.
Over all:		256	229	43.6

(Results based on 11,154.8 estimated total operate hours)

*Components having MTBA less than 1,120 hours. (see Chapter Three).

TABLE F-2

MEAN TIME BETWEEN FAILURE AND FAILURE RATE FOR MAJOR COMPONENTS OF GUN MOUNT
(less: Loaders, Slides, Housings, and Gun Barrels)
3 INCH 50 CALIBER MARK 33 MOD 0 GUN MOUNT
(For failures classifying the mount as non-operative and reduced operative)

Reliability Diagram No.	Component Name	No. of Failures	Failures (10,000Hr.)	MTBF (Hrs.)
1	Gun Mount	1	N.A.	N.A.
2	Stand	0	0	N.A.
3*	Carriage and shield	3	2.69	3,718
4*	Training gear assembly	2	1.79	5,577
5*	Elevation gear assembly	9	8.07	1,239
6	Magazines	1	.896	11,155
7	Mount drive power - main circuit breaker and associated circuits	2	1.79	5,577
8	Train drive electrical power circuits and power control parts	1	.896	11,155
9*	Gun training control circuits and control parts	3	2.69	3,718
10	Train receiver-regulator assembly	1	.869	11,155
11	Train amplidyne	2	1.79	5,577
12	Train Drive Motor	0	0	N.A.
13*	Train amplifier	13	11.7	858
14*	Parallax amplifier	14	12.6	797
15*	Field control circuits for train motor and train brake release control circuits	10	8.96	1,115
16*	DC power supply circuits for train drive amplifiers	6	5.38	1,859
17	Filament circuits for train amplifiers	0	0	N.A.
18	Elevation drive electrical power circuits and power control parts	0	0	N.A.
19	Gun elevation control circuits and control parts	2	1.79	5,577
20	Elevation receiver-regulator assembly	1	.896	11,155

*See comments in Chapter Three.

TABLE F-2 (continued)

Reliability Diagram No.	Component Name	No. of Failures	Failures Per (10,000Hr.)	MTBF (Hrs.)
21	Elevation amplidyne	1	.896	11,155
22	Elevation drive motor	1	.896	11,155
23*	Elevation amplifier	6	5.38	1,859
24*	Field control circuits for elevation motor and elevation brake release control circuits	3	2.69	3,718
25*	DC power supply circuits for elevation drive amplifiers	4	3.59	2,789
26	Filament circuits for elevation amplifiers	0	0	N.A.
	Over-all:	86	77.1	130

(Results based on 11,154.8 estimated total operate hours)

*See comments in Chapter Three.

TABLE F-3

MEAN ROUNDS BETWEEN ACTIONS AND ACTION RATES FOR MAJOR COMPONENTS OF LOADERS, SLIDES, HOUSINGS AND GUN BARRELS 3 INCH 50 CALIBER MARK 33 MOD 0 GUN MOUNT
(For all maintenance actions)

Reliability Diagram No.		No. of Actions	Action Rate (Per 10,000 Rds.)	MRBA (Rds.)
Loader Components (system of two loaders):				
27	Electrical power circuits and parts for loaders	5	1.07	9,309
28	Manual feed control, round alignment attachments and stop pins for (right and left loaders)	5	1.07	9,309
29*	Loader drive units (right and left loaders)	12	2.58	3,878
30*	Feed sprockets and drive mechanisms (right and left loaders)	31	6.66	1,501
31	Breech interlock mechanisms and linkages (right and left loaders)	1	.215	46,545
32	Front gate mechanisms and linkages (right and left loaders)	6	1.29	7,758
33	Rear gate mechanisms and linkages (right and left loaders)	1	.215	46,545
34*	Transfer tray and shell carriage mechanisms (right and left loaders)	20	4.30	2,327
35	Transfer tray arms and associated sideplate mechanisms (right and left loaders)	7	1.50	6,649
36	Buffer bar and shell deflector mechanisms (right and left loaders)	0	0	N.A.
42	Right and left loaders	4	N.A.	N.A.
Loaders over all:		92	19.77	506

*See comments in Chapter Three.

TABLE F-3 (continued)

Slides, Housings and Gun Barrels (system of two each):

Reliability Diagram No.	Component Name	No. of Actions	Action Rate (Per 10,000 Rds.)	MRBA (Rds.)
37	Slides and slide mechanisms (right and left guns)	6	1.29	7,758
38*	Gun housings and mechanisms (right and left guns)	37	7.95	1,258
39	Right-hand and left-hand guns	38	8.16	1,225
Slides, Housings, and Gun Barrels over all:		81	17.4	575
Overall rounds dependent components:		173	37.2	269

(Results based on 46,545 estimated total rounds cycled)

*See comments Chapter Three.

TABLE F-4

MEAN ROUNDS BETWEEN FAILURE AND FAILURE RATE FOR MAJOR COMPONENTS OF LOADERS, SLIDES, HOUSINGS AND GUN BARRELS
3 INCH 50 CALIBER MARK 33 MOD 0 GUN MOUNT
(For failures classifying the mount as non-operative and reduced operative)

Reliability Diagram No.	Component Name	No. of Failures	Failure Rate (per 10,000 Rds.)	MRBF (Rds.)
Loader Components (for a system of two loaders):				
27	Electrical power circuits and parts for loaders	1	.215	46,545
28	Manual feed control, round alignment attachments and stop pins for (right and left loaders)	3	.645	15,515
29*	Loader drive units (right and left loaders)	9	1.93	5,172
30*	Feed sprockets and drive mechanisms (right and left loaders)	12	2.58	3,878
31	Breech interlock mechanisms and linkages (right and left loaders)	0	0	N.A.
32	Front gate mechanisms and linkages (right and left loaders)	4	.859	11,636
33	Rear gate mechanisms and linkages (right and left loaders)	0	0	N.A.
34*	Transfer tray and shell carriage mechanisms (right and left loaders)	10	2.15	4,654
35	Transfer tray arms and associated side-plate mechanisms (right and left loaders)	5	1.07	9,309
36	Buffer bar and shell deflector mechanisms (right and left loaders)	0	0	N.A.
Loaders over-all:		44	9.45	1,158

*See comments in Chapter Three.

TABLE F-4 (continued)

Slides, Housings and Gun Barrels (system of two each):

Reliability Diagram No.	Component Name	No. of Failures	Failure Rate (per 10,000 Rds.)	MRBF (Rds.)
37	Slides and slide mechanisms (right and left guns	0	0	N.A.
38*	Gun housings and mechanisms (right and left guns)	13	2.79	3,580
39*	Right-hand and left-hand guns	0	0	N.A.
Slides, Housings and Gun Barrels over-all		13	2.79	3,580
Over-all rounds dependent components:		57	12.2	817

(Results based on 46,545 estimated total rounds)

*See comments in Chapter Three.

APPENDIX G

RELIABILITY INDICES FOR THE MOD 13 GUN MOUNT MAJOR COMPONENTS

TABLE G-1

MEAN TIME BETWEEN ACTIONS AND ACTION RATE FOR MAJOR COMPONENTS OF GUN MOUNT
(Less: Loaders, slides, housings and gun barrels)
3 INCH 50 CALIBER MARK 33 MOD 13 GUN MOUNT
(For all maintenance actions)

Reliability Diagram Number	Component Name	No. of Actions	Action Rate (per 10,000 hrs.)	MTBA (Hrs.)
1	Gun Mount	3	N.A.	N.A.
2	Stand	0	0	N.A.
3*	Carriage and Shield	19	28.5	351
4	Training gear assembly	2	3.00	3,335
5	Elevation gear assembly	5	7.50	1,334
6	Magazines	0	0	N.A.
7	Mount drive power - main circuit breaker and associated circuits	4	6.00	1,668
8*	Train drive electrical power circuits and power control parts	9	13.5	741
9	Gun training control circuits and control parts	1	1.50	6,671
10	Train receiver-regulator assembly	1	1.50	6,671
11	Train amplidyne	0	0	N.A.
12	Train drive motor	1	1.50	6,671
13*	Train amplifier	17	25.5	392
14*	Parallax amplifier	9	13.5	741
15*	Field control circuits for train motor and train brake release control circuits	18	27.0	371
16	DC power supply circuits for train drive amplifiers	5	7.50	1,334
17	Filament circuits for train amplifiers	0	0	N.A.

*MTBA less than 1,120 Hrs. - see Chapter Three.

(continued)

PRECEDING PAGE BLANK

TABLE G-1 (continued)

Reliability Diagram Number	Component Name	No. of Actions	Action Rate (per 10,000 hrs.)	MTBA (Hrs.)
18*	Elevation drive electrical power circuits and power control parts	8	12.0	834
19	Gun elevation control circuits and control parts	3	4.50	2,224
20	Elevation receiver-regulator assembly	1	1.50	6,671
21	Elevation amplidyne	1	1.50	6,671
22	Elevation drive motor	1	1.50	6,671
23*	Elevation amplifier	8	12.0	834
24*	Field control circuits for elevation motor and elevation brake release control circuits	10	15.0	667
25*	DC power supply circuits for elevation drive amplifiers	6	9.00	1,112
26	Filament circuits for elevation amplifiers	0	0	N.A.
Over all time dependent components:		132	197.9	50.5

(Results based on 6,670.86 estimated operate hours).

*MTBA less than 1,120 Hrs. - see Chapter Three.

116

TABLE G-2

MEAN TIME BETWEEN FAILURE AND FAILURE RATE FOR MAJOR COMPONENTS OF MOUNT

(Less: Loaders, slides, housings and gun barrels)

3 INCH 50 CALIBER MARK 33 MOD 13 GUN MOUNT

(For failures classifying the mount as non-operative and reduced operative)

Reliability Diagram Number	Component Name	No. of Failures	Failure Rate (per 10,000 Hrs.)	MTBF (Hrs.)
1	Gun Mount	2	N.A.	N.A.
2	Stand	0	0	N.A.
3*	Carriage and shield	5	7.50	1,334
4	Training gear assembly	1	1.50	6,671
5	Elevating gear assembly	2	3.00	3,335
6	Magazines	0	0	N.A.
7	Mount drive power - main circuit breaker and associated circuits	0	0	N.A.
8*	Train drive electrical power circuits and power control parts	5	7.50	1,334
9	Gun training control circuits and control parts	1	1.50	6,671
10	Train receiver-regulator assembly	1	1.50	6,671
11	Train amplidyne	0	0	N.A.
12	Train drive motor	0	0	N.A.
13*	Train amplifier	7	10.5	953
14*	Parallax amplifier	3	4.50	2,224
15*	Field control circuits for train motor and train brake release control circuits	15	22.5	445
16	DC power supply circuits for train drive amplifiers	5	7.50	1,134
17	Filament circuits for train amplifiers	0	0	N.A.
18*	Elevation drive electrical power circuits and power control parts	3	4.50	2,224

*See Chapter Three.

(continued)

TABLE G-2 (continued)

Reliability Diagram Number	Component Name	No. of Failures	Failure Rate (per 10,000 Hrs.)	MTBF (Hrs.)
19	Gun elevation control circuits	3	4.50	2,224
20	Elevation receiver-regulator assembly	1	1.50	6,671
21	Elevation amplidyne	0	0	N.A.
22	Elevation drive motor	0	0	N.A.
23*	Elevation amplifier	8	12.0	834
24*	Field control circuits for elevation motor and elevation brake release control circuits	10	15.0	667
25*	DC power supply circuits for elevation drive amplifiers	6	9.00	1,112
26	Filament circuits for elevation amplifiers	0	0	N.A.
Over all time dependent components:		78	117	85.5

(results based on 6,670.86 estimated operate hours.)

*See Chapter Three.

TABLE G-3

MEAN ROUNDS BETWEEN ACTIONS AND ACTION RATE FOR MAJOR COMPONENTS OF LOADERS, SLIDES, HOUSINGS, AND GUN BARRELS 3 INCH 50 CALIBER MARK 33 MOD 13 GUN MOUNT (For all maintenance actions)

Reliability Diagram Number	Component Name	No. of Actions	Action Rate (per 10,000 Rds.)	MRBA (Rds.)
Loader Components (system of two loaders):				
27*	Electrical power circuits and parts for loaders	6	2.52	3,967
28	Manual feed control, round alignment attachments and stop pins for (right and left loaders)	2	.840	11,901
29*	Loader drive units (right and left loaders)	8	3.36	2,975
30*	Feed sprockets and drive mechanisms (right and left loaders)	8	3.36	2,975
31	Breech interlock mechanisms and linkages (right and left loaders)	0	0	N.A.
32	Front gate mechanisms and linkages (right and left loaders)	1	.420	23,802
33	Rear gate mechanisms and linkages (right and left loaders)	0	0	N.A.
34*	Transfer tray and shell carriage mechanisms (right and left loaders)	4	1.68	5,950
35*	Transfer tray arms and associated side-plate mechanisms (right and left loaders)	5	2.10	4,760
36	Buffer bar and shell deflector mechanisms (right and left loaders)	2	.840	11,901
42	Right and left Loaders	2	N.A.	N.A.
Loaders over all (Mark 2 Mod 8):		38	16.0	626

*MRBA less than 4,000 rounds -- see Chapter Three.

(continued)

TABLE G-3 (continued)

Slides, Housings, and Gun Barrels (system of two each):

Reliability Diagram Number	Component Name	No. of Actions	Action Rate (per 10,000 Rds.)	MRBA (Rds.)
37*	Slides and slide mechanisms (right and left guns)	7	2.94	3,400
38*	Gun housings and mechanisms (right and left guns)	7	2.94	3,400
39*	Right-hand and left-hand guns	19	7.98	1,253
Overall slides, housings and gun barrels:		33	13.9	721
Overall rounds dependent components:		71	29.8	335

(Results based on 23,802 estimated rounds cycled)

*MRBA near or less than 4,000 rounds -- see Chapter Three.

TABLE G-4

MEAN ROUNDS BETWEEN FAILURE AND FAILURE RATES FOR MAJOR COMPONENTS OF LOADERS, SLIDES, HOUSINGS, AND GUN BARRELS 3 INCH 50 CALIBER MARK 33 MOD 13 GUN MOUNT (For failure classifying the mount as non-operative and reduced operative)

Reliability Diagram Number	Component Name	No. of Failures	Failure Rate (per 10,000 Rds.)	MRBF (Rds.)
Loader Components (system of two loaders:)				
27*	Electrical power circuits and parts for loaders	1	.420	23,802
28	Manual feed control, round alignment attachments and stop pins for (right and left loaders)	1	.420	23,802
29*	Loader drive units (right and left loaders	6	2.52	3,967
30*	Feed sprockets and drive mechanisms (right and left loaders)	4	1.68	5,951
31	Breech interlock mechanisms and linkages (right and left loaders)	0	0	N.A.
32	Front gate mechanisms and linkages (right and left loaders)	1	.420	23,802
33	Rear gate mechanisms and linkages (right and left loaders)	0	0	N.A.
34	Transfer tray and shell carriage mechanisms (right and left loaders)	3	1.26	7,934
35	Transfer tray arms and associated side-plate mechanisms (right and left loaders)	5	2.10	4,760
36	Buffer bar and shell deflector mechanisms (right and left loaders)	1	.420	23,802
42	Right and left Loaders	1	N.A.	N.A.
Loaders over all:	(Mark 2 MOD 8):	23	9.66	1,040

*See Chapter Three.

(continued)

TABLE G-4 (continued)

Slides, Housings, and Gun Barrels (system of 2 each)

Reliability Diagram Number	Component Name	No. of Failures	Failure Rate (per 10,000 Rds.)	MRBF (Rds.)
37*	Slides and slide mechanisms (right and left guns)	2	.840	11,901
38*	Gun housings and mechanisms (right and left guns)	5	2.10	4,760
39*	Right-hand and left-hand guns	0	0	N.A.
Over all slides, housings and gun barrels:		7	2.94	3,400
Over all rounds dependent components:		30	12.6	793

(Results based on 23,802 estimated rounds cycled)

*See Chapter Three.

APPENDIX H

ESTIMATED APPARENT GUN MOUNT RELIABILITY
MOD 0 AND MOD 13 GUN MOUNTS

TABLE H-1

ESTIMATED APPARENT GUN MOUNT RELIABILITY

Mark 33 Mod 0:		Failure Rate (per 10,000 Hrs.)	MTBF (Hrs.)	Action Rate (per 10,000 Hrs.)	MTBA (HRS.)
1.	Observed rates and data for time dependent components	77.1	129.7	229.5	43.6
2.	Apparent rates and data for loaders	39.4	253.8	82.5	121.1
3.	Apparent rates and data for slides, housings and gun barrels	11.7	858.0	72.6	137.7
		128.2		384.6	
4.	Over all apparent reliability	MTBF:	78.0	MTBA:	26.0

Mark 33 Mod 13:					
1.	Observed rates and data for time dependent components:	116.9	85.5	197.9	50.5
2.	Apparent rates and apparent data for loaders:	34.5	290.0	57.0	175.5
3.	Apparent rates and apparent data for slides, housings and gun barrels.	10.5	953.0	49.5	202.1
		161.9		304.4	
4.	Over all apparent reliability:	MTBF:	61.8 Hrs.	MTBA:	32.9 Hrs.

PRECEDING PAGE BLANK

TABLE H-2

COMPARISON OF MOD O AND MOD 13 RELIABILITY

Part A

Gun Mount Nomenclature	Class of Components	Total Actions	Total Failures	MTBA (Hrs.)	MTBF (Hrs.)	Total Estimated Operate Hrs.
Mark 33 Mod O	Time dependent	256	86	43.6	129.7	11,155
Mark 33 Mod 13	Time dependent	132	78	50.5	85.5	6,671
Difference				6.9	44.2	

Part B

Gun Mount Nomenclature	Class of Components	Total Actions	Total Failures	MRBA (Rds.)	MRBF (Rds.)	Total Estimated Rds. Cycled
Mark 33 Mod O	Rounds dependent	173	57	269	817	46,545
Loaders only		92	44	506	1,058	
Slides, Housings, and Gun Barrels		81	13	575	3,580	
Mark 33 Mod 13	Rounds dependent	71	30	335	793	23,802
Loaders only		38	23	626	1,035	
Slides, Housings, and Gun Barrels		33	7	721	3,400	
Differences						
Overall	Rounds dependent			66	24	
Loaders only				120	23	
Slides, Housings, and Gun Barrels				146	180	

Part C

Gun Mount Nomenclature	Class of Components	Total Actions	Total Failures	MTBA (Hrs.)	MTBF (Hrs.)	Total Estimated Operate Hrs.
Mark 33 Mod O Apparent Gun Mount:	All components	429	143	26.0	78.0	11,155
Mark 33 Mod 13 Apparent Gun Mount:	All Components	203	108	32.9	61.8	6,671
Difference:				6.90	16.2	

(continued)

TABLE H-2 (continued)

Part D

Gun Mount Nomenclature	Class of Components	Total Actions	Total Failures	MRBA (Rds.)	MRBF (Rds.)	Total Estimated Rds. Cycled
Mark 33 Mod 0 Apparent Gun Mount	All Components	429	143	108	325	46,545
Mark 33 Mod 13 Apparent Gun Mount	All Components	203	108	117	220	23,802
Difference				11	105	

APPENDIX I

MAINTAINABILITY INDEX VALUES

MAINTAINABILITY INDEX VALUES: MEAN MAN-HOURS TO REPAIR (MMHTR) 3 INCH 50 CALIBER GUN MOUNTS MARK 33 MOD 0 AND MARK 33 MOD 13

Reliability Diagram Block Number	Mod 0 Status						Mod 13 Status					
	Failure		Non-Failure		All Status		Failure		Non-Failure		All Status	
	Actions	MMHTR	Actions	MMHTR	Actions	MMHTR	Actions	MMHTR	Actions	MMHTR	Actions	MMHTR
1	1	N/A	3	N/A	4	N/A	2	N/A	1	N/A	3	N/A
2	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
3	3	1.70	13	7.00	16	6.01	5	139.	14	4.69	19	40.1
4	2	202.	8	8.44	10	47.2	1	2.00	1	0.400	2	1.20
5	9	6.06	10	3.44	19	4.68	2	3.00	3	93.6	5	57.4
6	1	1.50	0	N/A	1	1.50	0	N/A	0	N/A	0	N/A
7	2	15.0	4	0.880	6	5.58	0	N/A	4	10.3	4	10.3
8	1	0.100	1	1.00	2	0.550	5	3.74	4	11.2	9	7.10
9	3	32.4	15	4.87	18	9.45	1	1.60	0	N/A	1	1.60
10	1	10.0	1	1.00	2	5.50	1	7.00	0	N/A	1	7.00
11	2	3.00	1	1.00	3	2.33	0	N/A	0	N/A	0	N/A
12	0	N/A	1	1.00	1	1.00	0	N/A	1	0.500	1	0.500
13	13	8.51	20	2.35	33	4.77	7	1.89	10	3.68	17	2.94
14	14	8.36	18	3.02	32	5.36	3	2.33	6	2.57	9	2.49
15	10	6.64	16	1.73	26	3.61	15	6.19	3	21.0	18	8.66
16	6	9.67	14	1.91	20	4.24	5	1.14	0	N/A	5	1.14
17	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
18	0	N/A	0	N/A	0	N/A	3	11.5	5	7.34	8	8.90
19	2	39.8	6	0.960	8	10.7	3	1.90	0	N/A	3	1.90
20	1	1.00	2	2.05	3	1.70	1	4.20	0	N/A	1	4.20
21	1	4.00	0	N/A	1	4.00	0	N/A	1	1.00	1	1.00
22	1	6.00	0	N/A	1	6.00	0	N/A	1	0.500	1	0.500
23	6	19.2	15	3.69	21	8.12	8	3.95	0	N/A	8	3.95
24	3	0.100	9	1.71	12	1.31	10	9.33	0	N/A	10	9.33
25	4	14.3	13	1.63	17	4.60	6	0.950	0	N/A	6	0.950
26	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
27	1	1.00	4	1.30	5	1.24	1	100.	5	2.24	6	18.5
28	3	1.17	2	0.750	5	1.20	1	5.0	1	0.100	2	2.55
29	9	85.4	3	0.533	12	64.2	6	82.4	2	3.2	8	62.6
30	12	16.2	19	2.92	31	8.05	4	95.2	4	29.1	8	63.14
31	0	N/A	1	0.500	1	0.500	0	N/A	0	N/A	0	N/A
32	4	1.83	2	3.50	6	2.38	1	22.0	0	N/A	1	22.0
33	0	N/A	1	0.500	1	0.500	0	N/A	0	N/A	0	N/A
34	10	2.45	10	1.80	20	2.13	3	1.16	1	1.00	4	1.13
35	5	5.88	2	1.50	7	4.63	5	5.10	0	N/A	5	5.10
36	0	N/A	0	N/A	0	N/A	1	10.0	1	1.50	2	5.75
37	0	N/A	6	1.58	6	1.58	2	11.0	5	1.86	7	4.47
38	13	4.60	24	1.69	37	2.71	5	2.20	2	1.15	7	1.90
39	0	N/A	38	6.21	38	6.21	0	N/A	19	3.80	19	3.80
40	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
41	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
42	0	N/A	4	N/A	4	N/A	1	N/A	1	N/A	2	N/A

OVERALL:

Mod 0		Mod 13	
1. Total failure - status actions:	143	1. Total failure-status actions:	108
2. Total all-status actions:	429	2. Total all-status actions:	203
3. Total failure status man-hours:	2,754.2	3. Total failure status man-hours:	2,100.3
4. Total all status man-hours:	3,670.7	4. Total all-status man-hours:	2,911.5
5. Overall MMHTR, Mod 0:	8.6	5. Overall MMHTR, Mod 13:	14.3
6. Failure status MMHTR Mod 0:	19.3	6. Failure status MMHTR Mod 13:	19.4

APPENDIX J

MARK 33 MOD 13 GUN MOUNT
DETAILED REPLACED PARTS AND ADJUSTMENTS LISTING FOR LOADER MARK 2 MOD 8
RELIABILITY BLOCK DIAGRAM BLOCKS 28, 29, AND 30 WITH OBSERVED AND
HYPOTHETICAL ACTION RATES FOR GUN MOUNT SYSTEM

MARK 33 MOD 13 GUN MOUNT
DETAILED REPLACED PARTS AND ADJUSTMENTS LISTING FOR
LOADER MK 2 MOD 8 RELIABILITY DIAGRAM BLOCKS 28, 29, AND 30
WITH OBSERVED AND HYPOTHETICAL ACTION RATES FOR GUN MOUNT SYSTEM
(For a System Having 2 Loaders per Gun Mount)

Loader Mod No.	No. of Observed Actions	Action Taken (Replaced or Adjusted) and Part Name	Part Number	Federal Stock Number	IPB-1566 Figure and Index	Quantity Used Per Mount (Mod 6/8 -Mod 12)	Is Part or Adjustment Required On Mk 2 Mod 12?		Action Rate							
							Yes	No	Observed A_r (Per 10^4 Rds)	Observed A_t (Per 10^4 Hrs)	Adjusted A_r (Per 10^4 Rds)	Adjusted A_{t1} (Per 10^4 Hrs)	Adjusted A_{r2} (Per 10^4 Rds)	Adjusted A_{t2} (Per 10^4 Hrs)	Adjusted A_{r3} (Per 10^4 Rds)	Adjusted A_{t3} (Per 10^4 Hrs)
8	1	Replaced shaft return spring	511961-3	5360-597-2140	6-29	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	1	Replaced Gears and Lock Pins							.42013	1.49905	.04201	.14991	.10503	.37476	.10503	.37476
		Pin	610804	(No Ref)	7-97	4-4		X								
		40 Tooth Sliding Gear	610790	(No Ref)	7-105	4-4		X								
		40 Tooth Gear	610788	1015-710-120	7-98	4-4		X								
		40 Tooth Sliding Gear	610789	1015-710-121	7-106	2-2		X								
8	1	Replaced Oil Seal	33S44375-610	(No Ref)	11-27	1-1	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	1	Diagnosis of Sluggish Loader Operation	N/A	N/A	N/A	N/A	N/A	N/A	.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	4	Adjusted Loader, Replaced Shear Pin	513968-4	5315-276-4050	7-73	2-2	X		1.68053	5.99623	1.68053	5.99623	1.68053	5.99623	1.68053	5.99623
8	1	Replaced Fire Control Solenoid Assembly	LD168697/ 510033-2	5945-295-3235	9-32	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.10503	.37476
8	1	Replaced Roller Pin	511980-6	5315-807-3242	13-79	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	1	Replaced Rammer Drive Unit Clutch	511899-1	1015-384-2655	13-57	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	1	Adjusted Control Buffer Mechanism	LD168698/ 511915	(No Ref)	13-9	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	2	Replaced Gasket (Main Housing Top Cover)	884846	(No Ref)	15-7	2-2	X		.84027	2.99811	.84027	2.99811	.84027	2.99811	.84027	2.99811
8	1	Adjusted Drive Chain and Buffer Stops							.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
		Chain Take up Discs	612368-2 612368-1	(No Ref)	32-77 13-185	4-4	X									
		Upper Buffer Assy. RH	LD174395 511916-2	(No Ref)	23-43	2-2	X									
		Upper Buffer Assy. LH	LD174394 511916-1	(No Ref)	23-44	2-2	X									
		Lower Buffer Assy:	LD174399 511916-3	(No Ref)	21-5	2-2	X									
8	1	Replaced Roller Chain Assy.	510034-9	(No Ref)	9-30	2-2	X		.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
8	1	Replaced Spring and Lever							.42013	1.49905	.42013	1.49905	.42013	1.49905	.42013	1.49905
		Spring	511966-5	5360-205-4378	2-14	2-2	X									
		Lever	511966-1	1015-319-6469	2-9	2-2	X									
TOTALS	17								7.14223	25.18399	6.76411	24.13475	6.82713	24.3596	6.51203	23.23531

Rate Calculations Based On: Total Rounds cycled 23,802

Total Estimated Operating Hours 6,670.86

APPENDIX K

INCREMENTS OF MAINTAINABILITY IMPROVEMENT FOR MOD 0 AND MOD 13 GUN MOUNTS

TABLE K-1

3-INCH 50 CALIBER GUN MOUNT MARK 33 MOD 0
CHANGE IN MAINTAINABILITY FOR VARIOUS
GUN MOUNT IMPROVEMENT CASES

Case (See Footnote)	Reliability Block Diagram Number	Observed Number of Actions	Adjusted Number of Actions	Observed Total MMH	Adjusted Total MMH	Observed MMHTR	Adjusted MMHTR	MMHTR Difference	Observed MMH/Op. Hr.	Adjusted MMH/Op Hr.	MMH/Op. Hr. Difference	Percent Difference MMHTR	Percent Difference MMH/Op Hrs
Mark 33 Mod 0 Gun Mount (from Data including 11,1548 Operate Hours):													
	28	5	5	6.0	6.0	1.2	1.2	0.	.0005	.0005	0.	0.	0.
	29	12	12	770.6	518.6	64.2	43.2	-21.0	.0691	.0465	-.0226	-32.7	-32.7
	30	31	31	249.7	249.0	8.1	8.0	-.0226	.0224	.0223	-.00006	-.28	-.28
	All Others	381	381	2644.4	2644.4	6.9	6.9	0.	.2371	.2371	0.	0.	0.
1	1-(All Mount)	429	429	3670.7	3418.0	8.6	8.0	-0.6	.3291	.3064	-.0227	-6.88	-6.88
	28	5	5	6.0	6.0	1.2	1.2	0.	.0005	.0005	0.	0.	0.
	29	12	12	770.6	560.6	64.2	46.7	-17.5	.0691	.0503	-.0188	-27.3	-27.3
	30	31	31	249.7	249.1	8.1	8.0	-.0194	.0224	.0223	-.00005	-.240	-.240
	All Others	381	381	2644.4	2644.4	6.9	6.9	.0	.2371	.2371	0.	0.	0.
2	1-All Mount	429	429	3670.7	3460.1	8.6	8.1	-4909	.3291	.3102	-.0189	-5.74	-5.74
	28	5	5	6.0	3.8	1.2	0.76	-0.44	.0005	.0003	-.0002	-36.7	-36.7
	29	12	12	770.6	560.1	64.2	46.7	-17.5	.0691	.0502	-.0189	-27.3	-27.3
	30	31	31	249.7	243.5	8.1	7.9	-0.2	.0224	.0218	-.0006	-2.48	-2.48
	All Others	381	381	2644.4	2644.4	6.9	6.9	.0	.2371	.2371	0.	0.	0.
3	1-All Mount	429	429	3670.7	3451.8	8.6	8.0	.5103	.3291	.3094	-.0196	-5.96	-5.96
	11, 13-17, 21, 23-26	165	2	783.4	2	4.75	1.00	-3.75	.0702	.0002	-.0700	-78.9	-99.7
	All Others	264	264	2887.3	2887.3	10.9	10.9	0.	.2588	.2588	0.	0.	0.
5	1-Overall Mount	429	266	3670.7	2889.3	8.6	10.9	+2.306	.3291	.2590	-.0700	+26.9	-21.3

DEFINITION OF CASES:

1. Assume MMH for improved areas of loader will be 10% of observed MMH.
2. Assume MMH for improved areas of loader will be 25% of observed MMH.
3. Assume MMH for improved areas of loader and switch/solenoid actions will be 25% of observed MMH.
4. (Not computed above) Assume that the number of maintenance actions for the SCR Converter replacing the Mk 40 amplifiers and MG sets would be 2 and require 2 MMH total; and the loader and switch/solenoid area MMH are 25% of observed values.
5. Assume that the number of maintenance actions for the SCR Converter replacing the Mk 40 amplifiers and MG sets would be 2 and require 2 MMH total, and the MMH in other component areas minus the Mk 40 amplifiers and MG sets remain as observed.
6. (Not computed above) Assume that the number of maintenance actions for the SCR Converters replacing the Mk 40 amplifiers and MG sets would be 1 and require 1 MMH total, and the loader and switch/solenoid area MMH are 25% of observed values.
7. (Not computed above) Same as 5, above, except that the number of maintenance actions for the SCR Converters would be 1, as in 6 above.

NOTE:
1. The Cases 4, 6, 7, not computed, are included under definitions here only to preserve comparability with cases used previously when discussing reliability.
2. Minus signs indicate an adjusted index value which is less than the observed index and + signs indicate adjusted index value greater than the observed index.
3. The MMH/OH results are based on 11,154.8 operate hours.

TABLE K-2

3-INCH 50 CALIBER GUN MOUNT MARK 33 MOD 13
CHANGE IN MAINTAINABILITY WITH VARIOUS
CASES OF IMPROVEMENT

Case (See Footnote)	Reliability Block Diagram Number	Observed Number of Actions	Adjusted Number of Actions	Observed Total MMH	Adjusted Total MMH	Observed MMHTR	Adjusted MMHTR	MMHTR Difference	Observed MMH/Op. Hr.	Adjusted MMH/Op. Hr.	MMH/Op. Hr. Difference	Percent Difference MMHTR	Percent Difference MMH/Op. Hr.
Mark 33 Mod 13 Gun Mount (from data including 6,670.86 operate hours):													
	28	2	2	5.1	5.1	2.6	2.6	0	.0008	.0008	0.	0.	0.
	29	8	8	500.7	500.7	62.6	62.6	0	.0751	.0751	0.	0.	0.
	30	8	8	505.1	173.9	63.1	21.7	-41.40	.0757	.0261	-.0496	-65.6	-65.6
	All Others	185	185	1900.6	1900.6	10.3	10.3	0	.2849	.2849	0.	0.	0.
1	1-Overall Mount	203	203	2911.5	2580.3	14.3	12.7	-1.632	.4365	.3868	-0496	-11.4	-11.4
	28	2	2	5.1	5.1	2.6	2.6	0	.0008	.0008	0.	0.	0.
	29	8	8	500.7	500.7	62.6	62.6	0	.0751	.0751	0.	0.	0.
	30	8	8	505.1	229.1	63.1	28.6	-34.5	.0757	.0343	-.0414	-54.6	-54.6
	All Others	185	185	1900.6	1900.6	10.3	10.3	0	.2849	.2849	0.	0.	0.
2	1-Overall Mount	203	203	2911.5	2635.5	14.3	13.0	-1.360	.4365	.3951	-.0414	-9.48	-9.48
	28	2	2	5.1	5.1	2.6	2.6	0	.0008	.0008	0.	0.	0.
	29	8	8	500.7	500.6	62.6	62.6	-.0125	.0751	.0750	-.0001	-.020	-.020
	30	8	8	505.1	229.1	63.1	28.6	-34.5	.0757	.0343	-.0414	-54.6	-54.6
	All Others	185	185	1900.6	1900.6	10.3	10.3	0	.2849	.2849	0.	0.	0.
3	1-Overall Mount	203	203	2911.5	2635.4	14.3	13.0	-1.360	.4365	.3951	-.0414	-9.48	-9.48
	11, 13-17, 21, 23-26	74	2	368.5	2.0	4.98	1.00	-3.98	.0552	.0003	-.0549	-79.9	-99.5
	All Others	129	129	2543.0	2543.0	19.7	19.7	0	.3812	.3812	0.	0.	0.
5	1 Overall Mount	203	131	2911.5	2545.0	14.3	19.4	+5.09	.4365	.3815	-.0549	+35.5	-12.6

DEFINITION OF CASES:

1. Assume MMH for improved areas of loader will be 10% of observed MMH.
2. Assume MMH for improved areas of loader will be 25% of observed MMH.
3. Assume MMH for improved areas of loader and switch/solenoid actions will be 25% of observed MMH.
4. (Not computed above) Assume that the number of maintenance actions for the SCR Converter replacing the Mk 40 amplifiers and MG sets would be 2 and require 2 MMH total; and the loader and switch/solenoid area MMH are 25% of observed values.
5. Assume that the number of maintenance actions for the SCR Converter replacing the Mk 40 amplifiers and MG sets would be 2 and require 2 MMH total, and the MMH in other component areas minus the Mk 40 amplifiers and MG sets remain as observed.
6. (Not computed above) Assume that the number of maintenance actions for the SCR Converters replacing the Mk 40 amplifiers and MG sets would be 1 and require 1 MMH total, and the loader and switch/solenoid area MMH are 25% of observed values.
7. (Not computed above) Same as 5, above, except that the number of maintenance actions for the SCR Converters would be 1, as in 6 above.

NOTE:
1. The Cases 4, 6, 7, not computed, are included under definitions here only to preserve comparability with cases used previously when discussing reliability.
2. Minus signs indicate an adjusted index value which is less than the observed index and + signs indicate an adjusted index value greater than the observed index.
3. The MMH/OH results are based on 6670.86 operate hours.

APPENDIX L

OVERHAUL SCHEDULE FOR SHIPS
HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
7-9-73	12-3-73	Overcycled FY 78 Funded for FY 79	5 X 48	AF	22	Mauna Kea	2	0	Hunters Point	
7-11-73	2-15-74	Funded for FY 78	4.5 X 40	LKA	113	Charleston	2 2	0 13	Naval District 5	
7-16-73	12-14-73	Funded for FY 78	4.5 X 40	LPD	7	Cleveland	4	0	Naval District 11	
9-27-73	11-18-73	Overcycled FY 77 Funded for FY 78	5 X 40	LSD	40	Fort Fisher	2 2	0 13	Resident Supervisor, Long Beach	SCN limit 12-13-73
10-5-73	2-5-74		3 X 37	AF	58	Rigel	2	0	Philadelphia	
11-5-73	3-5-74	Funded for FY 78	4 X 44	LST	1182	Fresno	2	13	Naval District 13	
11-19-73	10-4-74	Funded for FY 78	9 X 37	DLG	24	Reeves	2	0	Pearl Harbor	
1-16-74	6-24-74	Funded for FY 78	4.5 X 40	LPD	13	Nashville	4	0	Norfolk, Va.	
1-21-74	6-10-74	Overcycled FY 78 Overcycled FY 79	5 X 48	AO	148	Ponchatoula	6	0	Guam	
2-4-74	7-15-74	Overcycled FY 78 Funded for FY 79	5 X 40	LSD	28	Thomaston	6	0	Long Beach	
2-8-74	7-9-74	Overcycled FY 78 Funded for FY 79	4.5 X 40	LPD	8	Dubuque	4	0	Long Beach	
2-11-74	8-12-74	Overcycled FY 79 Funded for FY 80	5 X 48	AE	27	Butte	2 2	0 13	Naval District 5	
2-18-74	8-11-74	Overcycled FY 78 Funded for FY 79	4 X 44	LST	1183	Peoria	2	13	Naval District 11	

(Continued)

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS

(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
3-25-74	9-12-74	Overcycled FY 78 Funded for FY 79	4 X 44	LST	1184	Federick	2	13	Naval District 11	
4-8-74	4-4-75	Funded for FY 78	9 X 37	DLG	17	Harry E. Yarnell	2	0	Philadelphia	
4-17-74	10-24-74	Overcycled FY 79	5 X 48	AO	147	Truckee	4	0	Naval District 5	
4-29-74	11-1-74	Funded for FY 79	7 X 37	DD	945	Hull	1	0	Long Beach	
5 -7-74	11-8-74	Overcycled FY 79	5 X 48	AFS	6	San Diego	2	13	Naval District 5	
6-24-74	1-6-75	Overcycled FY 79 Funded for FY 80	5 X 48	AE	21	Suribachi	2	0	Jacksonville	
6-28-74	1-17-75	Funded for FY 79	7 X 48	ACR	1	Wichita	2	13	Long Beach	
7-1-74	1-14-75	Overcycled FY 74 Funded for FY 78	4.5 X 40	LKA	117	El Paso	2 2	0 13	Naval District 5	
7-1-74	1-15-75	Overcycled FY 74 Overcycled FY 79 Funded for FY 80	7 X 48	ACE	3	Seattle	2 2	0 13	Norfolk, Va.	
7-8-74	10-31-74	Funded for FY 79	4 X 44	LST	1187	Tuscaloosa	2	13	Naval District 13	
7-8-74	11-8-74	Overcycled FY 74 Overcycled FY 78 Funded for FY 79	4.5 X 40	LKA	115	Mobile	2 2	0 13	Resident Supervisor, Long Beach	
8-1-74	2-12-75	Overcycled FY 78 Funded for FY 79	4.5 X 40	LPD	1	Raleigh	4	0	Naval District 5	

(Continued)

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS

(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
9-1-74	1-1-75	Overcycled FY 79 Funded for FY 80	4.5 X 40	LST	1185	Schenectady	2	13	Naval District 11	
9-3-74	3-12-75	Overcycled FY 74 Funded for FY 79	5 X 40	LSD	31	Point Defiance	6	0	Naval District 13	
9-3-74	6-20-75			AS	32	Holland	2	0	Puget	SSBN C-3 Conversion
9-4-74	3-1-75	Overcycled FY 74 Funded for FY 78	5.5 X 40	LPH	7	Guadalcanal	4	0	Philadelphia	
9-12-74	1-10-75	Overcycled FY 74 Overcycled FY 78 Funded for FY 79	4.5 X 40	LKA	116	St. Louis	2 2	0 13	Resident Supervisor, Long Beach	
10-1-74	3-8-75	Funded for FY 79	5 X 48	AFS	3	Niagara Falls	4	0	Naval District 12	
10-3-74	4-3-75	Overcycled FY 74 Funded for FY 79	4.5 X 40	LPD	10	Juneau	4	0	Naval District 11	
11-18-74	3-28-75	Overcycled FY 78 Funded for FY 80	5 X 40	LSD	33	Alamo	6	0	Naval District 11	
12-2-74	5-5-75	Overcycled FY 79 Funded for FY 80	4.5 X 40	LPD	11	Coronado	4	0	Naval District 5	
- -	- -	Overcycled FY 74 Overcycled FY 75	4 X 44	AGP	1176	Graham County	3	0		
- -	- -	Overcycled FY 75	5 X 48	AO	143	Neosho	4	0		
1-2-75	4-28-75	Overcycled FY 79	4 X 44	LST	1186	Cayuga	2	13	Long Beach	

(Continued)
OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
1-5-75	5-6-75	Overcycled FY 78 Funded for FY 79	4 X 44	LST	1179	Newport	2	13	Naval District 5	
1-5-75	5-6-75	Funded for FY 80	4 X 44	LST	1180	Manitowoc	2	13	Naval District 5	
1-6-75	7-7-75	Funded for FY 79	5 X 40	LSD	37	Portland	2 2	0 13	Naval District 5	
1-15-75	6-16-75		5 X 48	AC	145	Hassayampa	6	0	Naval District 13	
2-14-75	7-17-75	Overcycled FY 74 Funded for FY 79	5 X 40	LSD	30	Fort Snelling	6	0	Naval District 5	
3-1-75	8-2-75	Funded for FY 80	5 X 48	AFS	7	San Jose	2 2	0 13	Naval District 12	
3-21-75	8-22-75	Funded for FY 79	5.5 X 40	LPH	10	Tripoli	2	0	Naval District 11	
5-1-75	10-1-75	Funded for FY 80	7 X 48	AOR	3	Kansas City	1	13	Naval District 13	
5-15-75	3-1-76	Funded for FY 79	9 X 37	DLG	22	England	2	0	Puget Sound	
5-19-75	10-20-75	Overcycled FY 80	5 X 48	AFS	2	Sylvania	4	0	Naval District 5	
6-16-75	12-19-75	Overcycled FY 74 Overcycled FY 79 Funded for FY 80	5.5 X 40	LPH	9	Guam	4	0	Philadelphia	
6-23-75	2-20-76	Funded for FY 79	6 X 40	LCC	19	Blue Ridge	2	13	Long Beach	
7-1-75	2-2-76	Overcycled FY 80	5 X 48	AFS	4	White Plains	4	0	Sasebo	

(Continued)
OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
7-7-75	1-5-76	Funded for FY 80	4.5 X 40	LPD	5	Ogden	4	0	Naval District 13	
7-7-75	1-5-76	Overcycled FY 79 Funded for FY 80	5 X 40	LSD	35	Monticello	6	0	Resident Supervisor, Long Beach	
7-7-75	1-5-76		4 X 44	LST	1189	San Bernardino	2	13	Resident Supervisor, Long Beach	
7-7-75	1-5-76		4 X 44	LST	1191	Racine	2	13	Naval District 11	
8-1-75	12-1-75		4 X 40	LFA	249	Francis Marion	4	0	Naval District 3	
8-1-75	1-30-76	Overcycled FY 75 Funded for FY 80	5 X 40	LSD	29	Plymouth Rock	6	0	Naval District 5	
8-1-75	2-16-76	Overcycled FY 75 Overcycled FY 79	4 X 44	LST	1181	Sumter	2	13	Naval District 5	
8-15-75	4-15-76	Overcycled FY 75 Overcycled FY 80	4.5 X 40	LPD	14	Trenton	2 2	0 13	Naval District 5	
9-8-75	1-22-76		4.5 X 40	LKA	112	Tulare	6	0	Naval District 11	
11-3-75	5-3-76	Overcycled FY 80	4.5 X 40	LKA	114	Durham	2 2	0 13	Naval District 13	
11-3-75	6-30-76	Overcycled FY 80	5 X 48	AE	24	Pyro	2	0	Mare Island	
11-10-75	5-10-76	Overcycled FY 75 Overcycled FY 79 Funded for FY 80	5 X 40	LSD	38	Pensacola	2 2	0 13	Naval District 5	

(Continued)

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIPER MARK 33 GUN MOUNTS

(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
11-14-75	5-17-76	Funded for FY 80	4 X 44	LST	1188	Saginaw	2	13	Naval District 5	
11-14-75	7-30-76	Funded for FY 80	5 X 48	AE	29	Mount Hood	2 2	0 13	Naval District 12	
12-8-75	10-11-76	Overcycled FY 79 Funded for FY 80	7 X 37	DD	931	Forrest Sherman	1	0	Norfolk, Va.	
- -	- -	Overcycled FY 77 Funded for FY 78	7 X 37	DD	942	Bigelow	1	0		
1-2-76	9-2-76	Overcycled FY 75	5 X 60	AS	34	Canopus	2	0	Charleston	
1-5-76	10-20-76	Funded for FY 80	7 X 37	DD	946	Edson	1	0	Long Beach	
1-19-76	10-8-76	-	5 X 48	AE	28	Santa Barbara	2 2	0 13	Jacksonville	
2-2-76	9-1-76	Overcycled FY 75 Funded for FY 80	5 X 40	AGF	3	La Salle	4	0	Naval District 5	
2-9-76	6-23-76		4.5 X 40	LPA	248	Paul Revere	4	0	Naval District 12	
2-16-76	8-16-76	Overcycled FY 80	4 X 44	LST	1192	Spartanburg County	2	13	Naval District 5	
2-20-76	12-6-77	Overcycled FY 75 Funded for FY 80	9 X 37	DLG	18	Worden	2	0	Yokohama	
3-1-76	10-1-76		5 X 48	AFS	1	Mars	2 2	0 13	Sasebo	
3-1-76	10-15-76	Funded for FY 80	5.5 X 40	LPH	11	New Orleans	2 2	0 13	Naval District 11	

(Continued)
OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
3-5-76	12-20-76	Funded for FY 80	7 X 37	DD	951	Turner Joy	1	0	Long Beach	
3-11-76	10-26-76	Overcycled FY 75 Funded for FY 80	4.5 X 40	LPD	12	Shreveport	4	0	Naval District 5	
4-1-77	10-3-77	Overcycled FY 76	3 X 37	AF	59	Vega	2	0	Naval District 12	
4-1-77	12-1-77	Overcycled FY 76	7 X 48	ACE	1	Sacramento	4	0	Naval District 13	
4-5-76	11-19-76	Overcycled FY 75	7 X 48	AOE	4	Detroit	2 2	0 13	Philadelphia	
4-16-76	10-29-76	Overcycled FY 75 Overcycled FY 80	5.5 X 40	LPH	12	Inchon	1 1	0 13	Norfolk, Va.	
6-1-76	4-1-77		7 X 48	AOE	2	Camden	4	0	Puget Sound	
7-1-76	8-16-76	Overcycled FY 79 Funded for FY 80	9 X 37	DLG	10	King	2	0	Charleston	Post shakedown availability; complex overhaul - see OPNAVINST 4700.7E
7-1-76	12-15-76		5 X 40	LSD	39	Mount Vernon	2 2	0 13	Naval District 13	
7-9-76	1-10-77	Overcycled FY 80	4.5 X 40	LPD	6	Duluth	4	0	Resident Supervisor, Long Beach	
7-12-76	1-14-77		4 X 44	LST	1195	Barbour County	2	13	Naval District 11	
7-16-76	4-18-77	Overcycled FY 76	7 X 48	ACP	4	Savannah	2	13	Norfolk, Va.	

(Continued)

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates From	To	Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns Qty.	Mod.	Shipyard or Overhaul Authority	Other Schedule Notes
7-30-76	3-15-77		5 X 48	AE	26	Kilauea	2 2	0 13	Naval District 12	
8-2-76	1-31-77	Overcycled FY 76	4 X 44	LST	1193	Fairfax County	2	13	Naval District 5	
9-1-76	3-17-77	Overcycled FY 76	5 X 40	LSD	32	Spiegel Grove	6	0	Naval District 5	
9-15-76	3-17-77	Overcycled FY 76 Overcycled FY 80	5.5 X 40	LPH	2	Iwo Jima	2	0	Norfolk,Va.	
9-22-76	3-15-77	Overcycled FY 76	4 X 44	LST	1190	Boulder	2	13	Naval District 5	
9-30-76	11-15-76			DLGN	25	Bainbridge	2	0	Puget Sound	Post shakedown availabilit
10-1-76	5-16-77		5 X 48	AE	23	Nitro	2	0	Naval District 3	
10-8-76	3-23-77		4.5 X 40	LPD	4	Austin	4	0	Naval District 5	
11-15-76	10-14-77	Overcycled FY 76	9 X 37	DLG	20	Richmond K. Turner	2	0	Norfolk, Va.	Complex overhaul - see OPNAVINST 4700.7E
12-1-76	3-1-78	Overcycled FY 76	9 X 37	DLG	16	Leahy	2	0	Pearl Harbor	
- -	- -	Overcycled FY 77 Funded for FY 78	5 X 48	AE	25	Haleakala	2	0		
- -	- -	Overcycled FY 77 Funded for FY 78	5 X 48	AE	33	Shasta	2 2	0 13		
- -	- -	Overcycled FY 77 Funded for FY 78	5 X 48	AFS	5	Concord	4	0		
- -	- -	Overcycled FY 77 Overcycled FY 78	5 X 48	AO	144	Mississinewa	4	0		

(Continued)
OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
- -	- -	Overcycled FY 77 Overcycled FY 78	5 X 48	AO	146	Kawishiwi	6	0		
- -	- -	Overcycled FY 77	7 X 48	ACR	5	Wabash	2	13		
- -	- -	Overcycled FY 77 Funded for FY 78	7 X 37	DD	944	Mullinnix	1	0		
- -	- -	Overcycled FY 77 Funded for FY 78	9 X 37	DLG	21	Gridley	2	0		
- -	- -	Overcycled FY 77 Funded for FY 78	4.5 X 40	LPD	9	Denver	4	0		
- -	- -	Overcycled FY 77 Funded for FY 78	5.5 X 40	LPH	3	Okinawa	2	0		
- -	- -	Overcycled FY 77	5 X 40	LSD	36	Anchorage	2 2	0 13		
- -	- -	Overcycled FY 77 Funded for FY 78	4 X 44	LST	1196	Harlan County	2	13		
- -	- -	Overcycled FY 77 Funded for FY 78	4 X 44	LST	1197	Barnstable County	2	13		
- -	- -	Overcycled FY 77 Funded for FY 78	4 X 44	LST	1198	Bristol County	2	13		
1-7-77	12-7-77	Overcycled FY 76	9 X 37	DLG	19	Dale	2	0	Philadelphia	Complex overhaul see CPNAVINST 4700.7E
1-14-77	9-14-77	Overcycled FY 76	4.5 X 40	LPD	15	Ponce	2 2	0 13	Naval District 5	

(Continued)

OVERHAUL SCHEDULE FOR SHIPS HAVING 3 INCH 50 CALIBER MARK 33 GUN MOUNTS
(COMBINED ATLANTIC AND PACIFIC FLEET SCHEDULES)

Overhaul Schedule Dates		Overcycle or Funding Notes	Overhaul-Operate Cycle	Ship Type	Hull No.	Ship Name	MK 33 Guns		Shipyard or Overhaul Authority	Other Schedule Notes
From	To						Qty.	Mod.		
2-15-77	8-16-77	Overcycled FY 76	4 X 44	LST	1194	La Moure County	2	13	Naval District 5	
2-15-77	10-1-77		5 X 48	AE	32	Flint	2 2	0 13	Naval District 12	
3-1-77	9-1-77		5 X 40	LSD	34	Hermitage	6	0	Naval District 5	
3-2-77	11-2-77		5 X 60	AS	33	Simon Lake	2	0	Charleston	
3-30-77	10-14-77	Overcycled FY 76 Overcycled FY 80	4.5 X 40	LPD	2	Vancouver	4	0	Resident Supervisor, Long Beach	
5-6-77	4-6-78	Funded for FY 78	9 X 37	DLG	23	Halsey	2	0	Long Beach	
- -	- -	Overcycled FY 78	5 X 48	AE	35	Kiska	4	13		
- -	- -	Overcycled FY 78 Overcycled FY 79 Funded for FY 80	6 X 37	DE	1038	McCloy	1	13		
- -	- -	Funded for FY 78	5 X 48	AE	34	Mount Baker	4	13		
- -	- -	Overcycled FY 78 Funded for FY 79	6 X 40	LCC	20	Mount Whitney	2	13		Complex overhaul see OPNAVINST 4700.7F
- -	- -	Overcycled FY 79 Funded for FY 80	6 X 37	DE	1037	Bronstein	1	13		
- -	- -	Funded for FY 79	7 X 48	AOR	6	Kalamazoo	2	13		
- -	- -	Funded for FY 80	7 X 48	AOR	2	Milwaukee	2	13		
- -	- -		5 X 48	AF	56	Denebola	2	0		Not scheduled FY 74 - FY 80

APPENDIX M

ORDNANCE LOGISTICS INFORMATION SYSTEM
(SHIPS MDCS SUB-SYSTEM)
3"/50 MK 33 GUN MOUNT
RELIABILITY-MAINTAINABILITY-AVAILABILITY
SUMMARY REPORT
JULY 1972 - JUNE 1974
PREPARED BY OMMIC, WPNSTA CONCORD, CALIFORNIA

SURFACE WARFARE WEAPON SYSTEMS
RELIABILITY-MAINTAINABILITY-AVAILABILITY
GUN MOUNT SUMMARY

GOLD	** MOUNT, 3 IN, 50CAL, TWIN RF MK 33 MODS 0 TO 13 **				LEVEL	LIMIT
DATE RANGE	JUL-SEP 72	OCT-DEC 72	JAN-MAR 73	APR-JUN 73		
ACTIVE EQUIPMENT POPULATION (SAMPLE POPULATION)	230	232	222	222		
EQUIPMENT STRESS						
TOTAL ESTIMATED OPERATE TIME (HRS)	12680.0	11567.0	17827.0	10333.0		
TOTAL ROUNDS FIRED	11124	8282	6322	10141		
PLANNED MAINTENANCE TOTALS (REQUIRED PMS)						
EVENTS	12341	12151	12210	12210		
MAN-HOURS	28697.4	29266.8	28086	28603		
MDCS CORRECTIVE MAINTENANCE (CM) TOTALS						
OPERATIONAL (STATUS 1)						
EVENTS	86	72	149	171		
MAN-HOURS	419.6	295.7	1114.2	506.5		
ART (HRS)	209.8	147.8	557.1	253.3		
REDUCED CAPABILITY (STATUS 3)						
CM ACTIONS	117	54	75	90		
MAN-HOURS	759.8	1136.4	875.5	575.4		
ART (HRS)	379.9	568.2	437.7	287.5		
NON-OPERATIONAL (STATUS 2)						
CM ACTIONS	80	51	78	85		
MAN-HOURS	948.2	565.3	660.8	1312.0		
ART (HRS)	474.1	282.6	330.3	656.0		
CASREPT CM ACTIONS (NOT REPORTED VIA MDCS)	16	13	17	10		
RELIABILITY						
TOTAL CM ACTIONS (STATUS 2 & 3 & CASREPTS)	213	118	170	185		
MEAN TIME BETWEEN CM ACTIONS (MTBCM) WHERE FIRING RATE = 25ROUNDS/HOUR	3.6	4.9	5.5	6.2		
RELIABILITY FUNCTION R(T) WHERE T = 1 HOUR	0.7592	0.8155	0.8337	0.8469		
T = 8 HOURS	0.1104	0.1956	0.2335	0.2646		
MAINTAINABILITY						
DOWNTIME (HRS)						
MEAN TIME TO REPAIR (MTTR)	4.3	8.1	5.0	5.4		
PARTS DELAYS FOR	36	51	82	43		
MEAN DELAY TIME	697.2	932.4	612.6	651.7		
OUTSIDE ASSISTANCE DELAYS FOR	31	26	40	37		
MEAN DELAY TIME	1379.1	997.1	963.0	815.0		
SHIPS' OPERATIONS DELAYS FOR	24	2	15	22		
MEAN DELAY TIME	1304.7	244.0	680.6	920.3		
MEAN DOWNTIME (MDT)	283.1	404.3	354.0	253.1		
MAINTAINABILITY FUNCTION M(T) WHERE T = 1 HOUR	0.5190	0.3846	0.4413	0.5251		
T = 3 HOURS	0.7130	0.6731	0.7434	0.7054		
AVAILABILITY						
INTRINSIC AVAILABILITY A(I)	0.9321	0.9236	0.9543	0.9485		
OPERATIONAL AVAILABILITY A(O)	0.1737	0.1953	0.2245	0.2610		
USE AVAILABILITY A(U)	0.8582	0.8726	0.8541	0.8504		

PREPARED BY ... NAVAL WEAPONS STATION, CONCORD CALIF DATE: 23-...-74 OMBLIS NO 1 AB 700 PAGE: 1

BEST AVAILABLE COPY

PRECEDING PAGE BLANK

SURFACE WARFARE WEAPON SYSTEMS
RELIABILITY-MAINTAINABILITY-AVAILABILITY
GUN MOUNT SUMMARY

GELJ ** MOUNT, 3 IN. 50CAL. TWIN RF MK 33 MODS 0 TO 13 ** LEVEL LIMIT

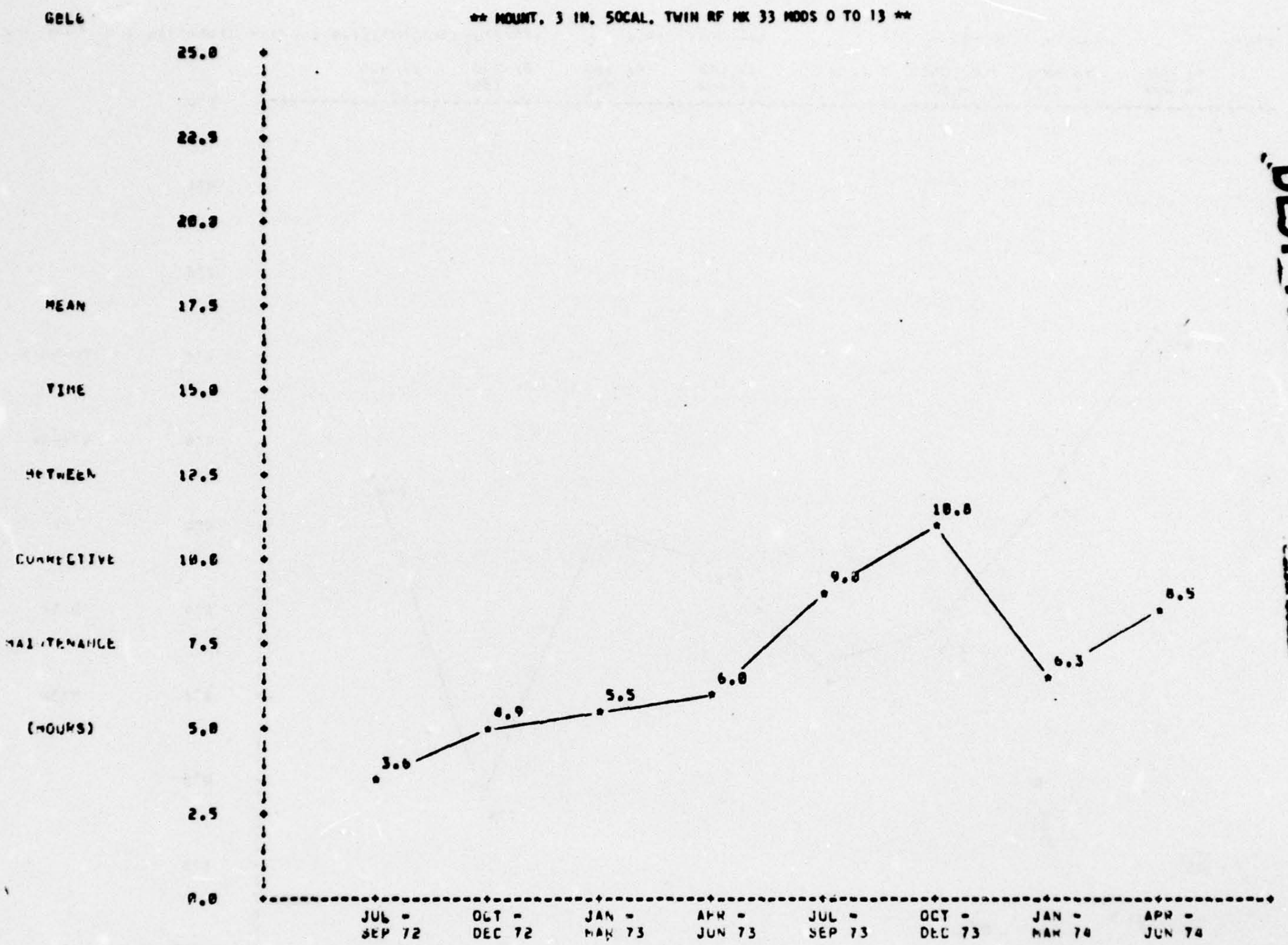
DATE RANGE	JUL-SEP 73	OCT-DEC 73	JAN-MAR 74	APR-JUN 74	LEVEL	LIMIT
ACTIVE EQUIPMENT POPULATION (SAMPLE POPULATION)	213	214	397	381		
EQUIPMENT STRESS						
TOTAL ESTIMATED OPERATE TIME (HRS)	17469.0	17545.0	29256.0	31225.0		
TOTAL ROUNDS FIRED	12461	6026	14216	14479		
PLANNED MAINTENANCE TOTALS (REQUIRED PMS)						
EVENTS	11550	11770	21835	20995		
MANHOURS	26491	26994	50138	48136		
3-M CORRECTIVE MAINTENANCE (CM) TOTALS						
OPERATIONAL (STATUS 1)						
EVENTS	112	75	165	176		
MANHOURS	309.8	233.9	1255.5	856.8		
MTT (HRS)	154.9	117.0	627.7	428.4		
REDUCED CAPABILITY (STATUS 3)						
CM ACTIONS	46	45	152	101		
MANHOURS	279.2	345.9	1336.2	259.2		
MTT (HRS)	139.6	173.0	668.1	134.6		
NONOPERATIONAL (STATUS 2)						
CM ACTIONS	76	55	89	92		
MANHOURS	1319.1	647.1	828.5	741.5		
MTT (HRS)	659.6	323.5	414.3	370.7		
CASREPT CM ACTIONS (NOT REPORTED VIA MDCS)	7	6	24	13		
RELIABILITY						
TOTAL CM ACTIONS (STATUS 2 & 3 & CASREPTS)	129	86	265	206		
MEAN TIME BETWEEN CM ACTIONS (MTBCM) WHERE						
FAILURE RATE = FAILURES/HOUR	[illegible]	1.8	8.3	8.5		
RELIABILITY FUNCTION R(T) WHERE T = 1 HOUR	[illegible]	0.9115	0.8573	0.8884		
T = 6 HOURS	0.4114	0.4756	0.2764	0.3581		
MAINTAINABILITY						
(TIME IN HRS)						
MEAN TIME TO REPAIR (MTTR)	6.5	5.2	4.5	2.6		
PARTS DELAYS FOR	56	16	56	55		
MEAN DELAY TIME	665.6	585.7	790.5	681.6		
OUTSIDE ASSISTANCE DELAYS FOR	31	13	64	43		
MEAN DELAY TIME	946.5	644.4	1217.9	739.0		
SHIPS' OPERATIONS DELAYS FOR	5	4	18	7		
MEAN DELAY TIME	1126.4	719.3	701.3	665.2		
MEAN DOWNTIME (MDT)	482.3	253.6	349.9	321.6		
MAINTAINABILITY FUNCTION M(T) WHERE T = 1 HOUR	0.6584	0.6529	0.4855	0.6529		
T = 3 HOURS	0.7967	[illegible]	0.8135	0.8497		
AVAILABILITY						
INHERENT AVAILABILITY A(I)	0.9534	0.9705	[illegible]	0.9550		
OPERATIONAL AVAILABILITY A(O)	0.2423	0.4459	0.2346	0.3543		
[illegible] AVAILABILITY A(G)	0.8467	[illegible]	[illegible]	0.9111		

[illegible]
[illegible] STATION, CORONA CALIF [illegible]

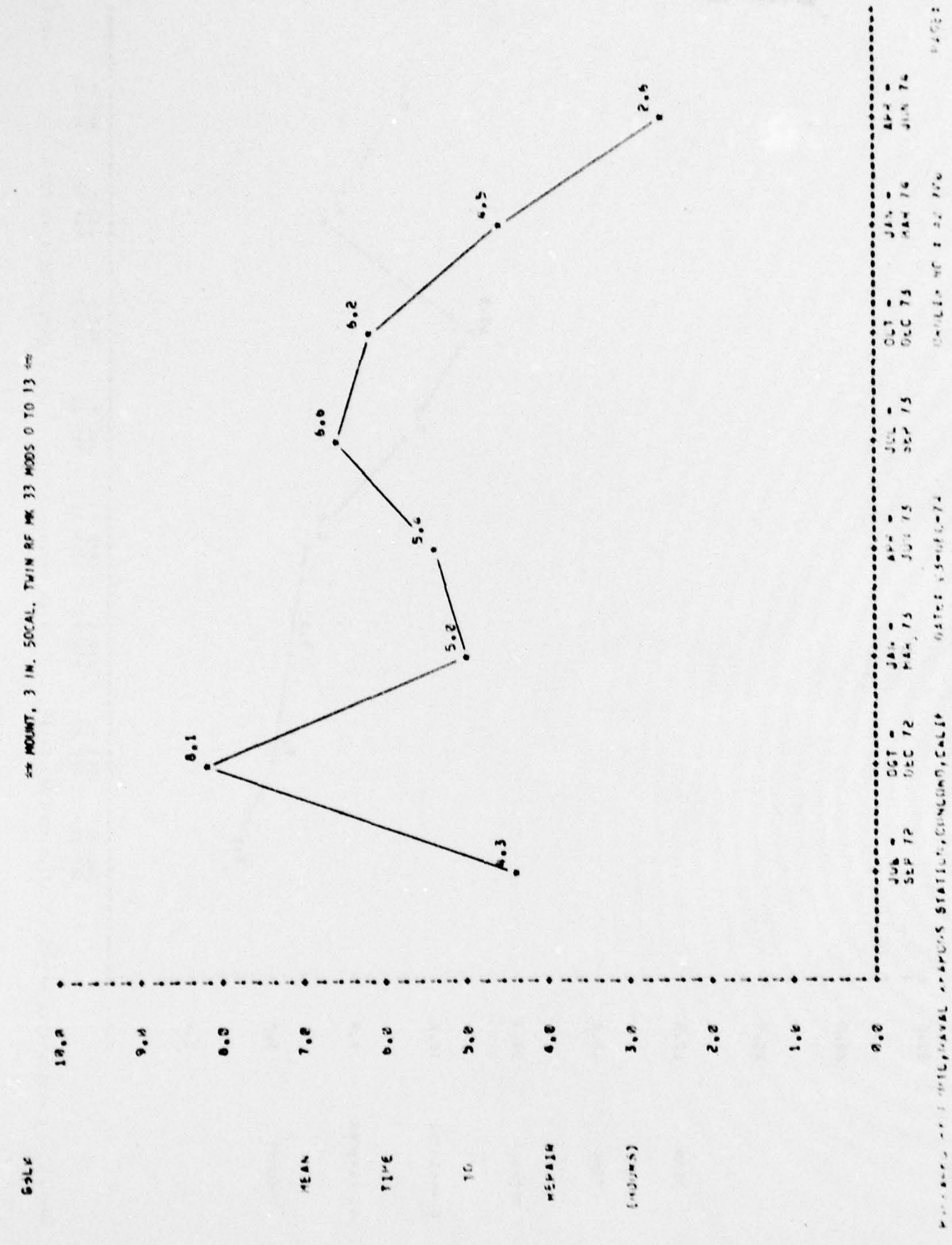
M-4

BEST AVAILABLE COPY

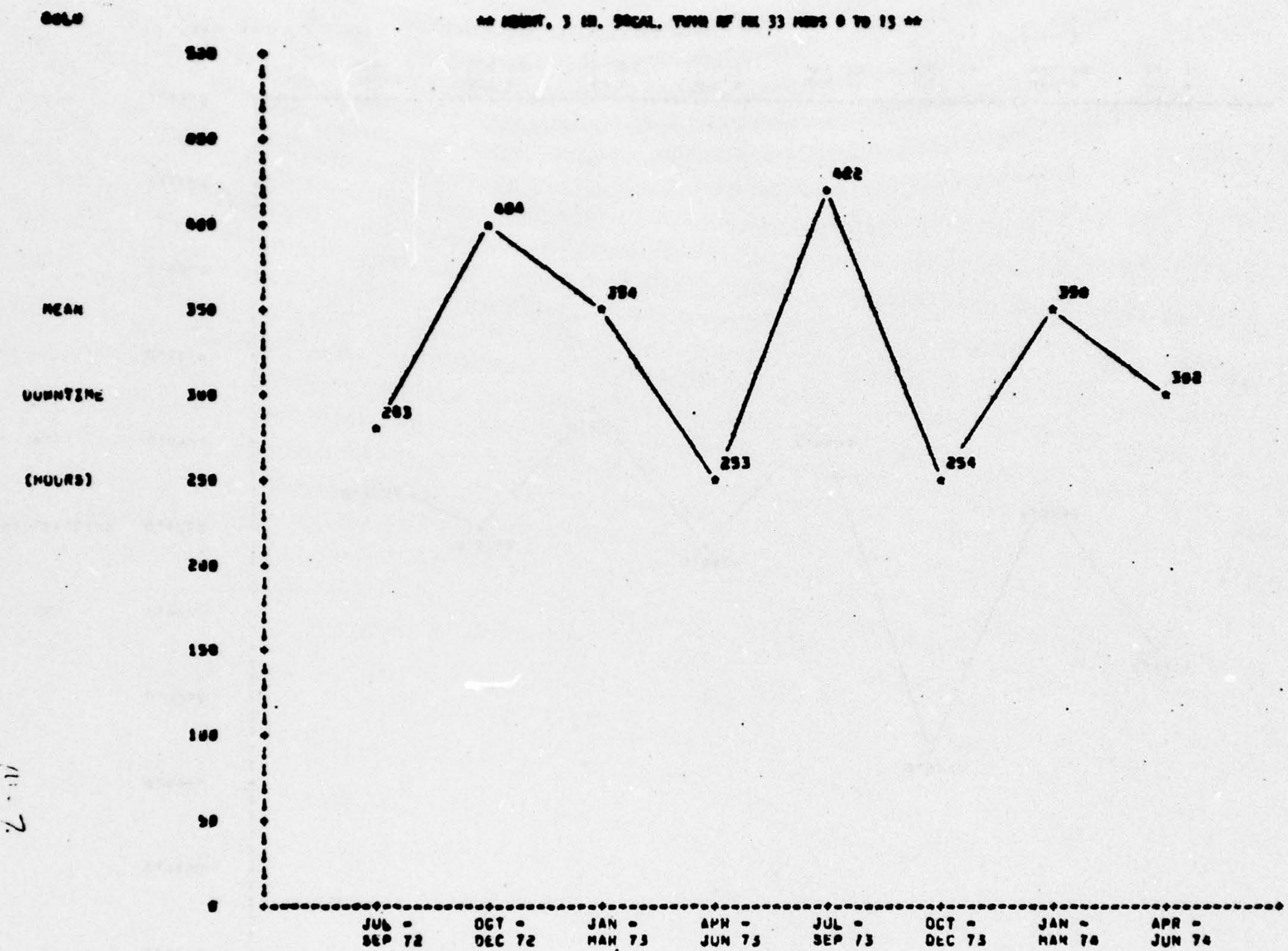
** MOUNT, 3 IN. 50CAL. TWIN RF MK 33 MODS 0 TO 13 **



PREPARED BY DPMIC, NAVAL WEAPONS STATION, CONCORD, CALIF   DATE: 03-DEC-74   ORDLIS NO 1 AD 700   PAGE: 1

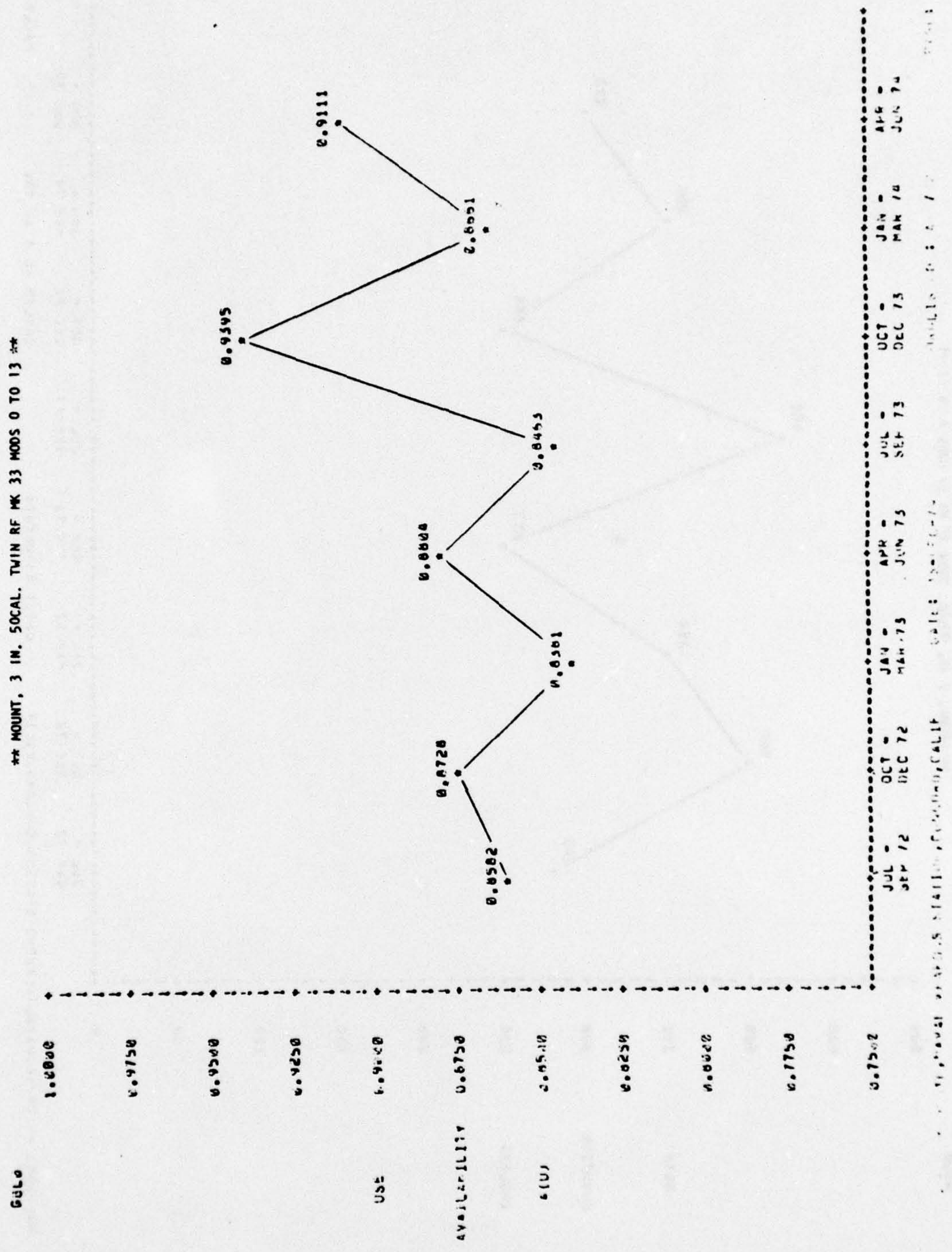


BEST_AVAILABLE_COPY



PREPARED BY DMMIC,NAVAL WEAPONS STATION,CONCORD,CALIF DATE: 03-DEC-74 DHDLIS NO 1 A2 7RU PAGE: 3

M-7



BEST AVAILABLE COPY

RELIABILITY-MAINTAINABILITY-AVAILABILITY
GUN MOUNT SUMMARY

DATA CONTROLS AND DEFINITION OF TERMS

PREPARED BY OMMIC, NAVAL WEAPONS STATION, CONCORD, CALIF ORDLIS NO. A0700

DATE RANGE	TIME SPAN USED TO SELECT DATA. MDCS DOCUMENTS (OPNAV FORM 4790/2K) ARE SELECTED BY WHEN DISCOVERED DATE - CASREPT DOCUMENTS BY CASREPT DATE TIME GROUP.
ACTIVE EQUIPMENT POPULATION	NUMBER OF EQUIPMENTS WHICH WERE ACTIVE AT LEAST ONE DAY OF THE QUARTER. AN EQUIPMENT IS NOT CONSIDERED ACTIVE WHEN IT IS ABOARD A NAVAL RESERVE TRAINING SHIP OR DURING THE TIME A SHIP IS IN THE FOLLOWING NON-AVAILABLE EMPLOYMENTS: CONSTRUCTION CONVERSION DECOMMISSION FITTING OUT INACTIVE INTERIM DRY DOCKING RESTRICTED SHIPYARD AVAILABILITY - DRY DOCKING RESTRICTED AVAILABILITY OVERHAUL PREOVERHAUL TENDER AVAILABILITY LEAVE AND UPKEEP HOLIDAY & LEAVE HOLIDAY & UPKEEP
EQUIPMENT STRESS	
TOTAL ESTIMATED OPERATE TIME	TOTAL ENERGIZED TIME EXPRESSED IN HOURS. ENERGIZED TIME IS DEFINED AS THE TIME ANY SECTION (ELECTRICAL, HYDRAULIC, OR MECHANICAL) OF THE GUN MOUNT IS OPERATING FOR ANY REASON. SINCE TIME METER DATA FOR GUN MOUNTS IS NOT AVAILABLE, ESTIMATES OF ENERGIZED TIME IN VARIOUS EMPLOYMENT MODES WERE OBTAINED FROM FLEET GUNNERY PERSONNEL. THESE ESTIMATES WERE COMBINED WITH EMPLOYMENT DATA FROM THE SHIP EMPLOYMENT FILE TO DEVELOP TOTAL OPERATE TIME.

TOTAL ROUNDS FIRED	TOTAL PROJECTILES FIRED BY ALL ACTIVE GUN MOUNTS.
PLANNED MAINTENANCE TOTALS (REQUIRED PMS)	DERIVED FROM MAINTENANCE INDEX PAGES (OPNAV FORM 47ØØ-3 (A)).
EVENTS	TOTAL PLANNED MAINTENANCE ACTIONS FOR ALL EQUIPMENTS AS SCHEDULED ON MAINTENANCE REQUIRED CARDS (MRC'S).
MAN-HOURS	ESTIMATED MAN-HOURS REQUIRED FOR PMS EVENTS FOR ALL ACTIVE EQUIPMENTS.
MDCS CORRECTIVE MAINTENANCE (CM) TOTALS	CORRECTIVE MAINTENANCE AS REPORTED ON OPNAV FORM 479Ø/2K. DOCUMENTS INITIATED DURING NON-AVAILABLE EMPLOYMENTS AND THOSE WITH THE FOLLOWING DATA ELEMENTS ARE EXCLUDED: CARD TYPE A - ALTERATIONS ACTION TAKEN CODES 3 - CANCELLATION 9 - CONFIGURATION CHANGE (ORDALTS) STATUS CODES Ø - NO MALFUNCTION 4 - PMS CAUSE CODES Ø - NO MALFUNCTION 1 - FIRE/COLLISION/BATTLE/STORM DAMAGE FIRST INDICATION OF TROUBLE CODES ALPHA IN FIRST DIGIT - PMS PERIODICITY MDCS CORRECTIVE MAINTENANCE TOTALS ARE SHOWN FOR THE FOLLOWING CATEGORIES:
OPERATIONAL (STATUS 1)	EQUIPMENT FULLY OPERATIONAL WHEN MAINTENANCE ACTION WAS INITIATED.
REDUCED CAPABILITY (STATUS 3)	EQUIPMENT OPERATING AT REDUCED CAPABILITY DUE TO MALFUNCTION OR FAILURE.
NON-OPERATIONAL (STATUS 2)	EQUIPMENT NON-OPERATIONAL DUE TO MALFUNCTION OR FAILURE.

EVENTS	TOTAL MAINTENANCE EVENTS REPORTED FOR STATUS CODE 1.
CM ACTIONS	TOTAL CORRECTIVE MAINTENANCE ACTIONS REPORTED FOR STATUS CODES 2 & 3.
MAN-HOURS	TOTAL CORRECTIVE MAINTENANCE MAN-HOURS REPORTED FOR EACH STATUS CODE.
AMT	ACTIVE MAINTENANCE TIME - TOTAL CLOCK-HOURS DURING WHICH CORRECTIVE MAINTENANCE WAS BEING PERFORMED FOR EACH STATUS CODE.
CASREPT CM ACTIONS (NOT REPORTED VIA MDCS)	TOTAL CORRECTIVE MAINTENANCE ACTIONS REPORTED VIA THE CASREPT SYSTEM, BUT NOT IN MDCS.

RELIABILITY

TOTAL CM ACTIONS	MDCS STATUS CODE 2 & 3 CM ACTIONS PLUS CASREPT ACTIONS NOT REPORTED IN MDCS.
MEAN TIME BETWEEN CM ACTIONS (MTBCM)	EXPRESSED IN HOURS FOR A SPECIFIED FIRING RATE TO ALLOW FOR COMPARISON BETWEEN QUARTERS.

$$\text{MTBCM} = \frac{1}{\text{FAILURE RATE (L)}}$$

$$= \frac{1}{\text{TIME FAILURE RATE} + \text{CYCLIC FAILURE RATE}} \quad \text{WHERE}$$

$$\text{TIME FAILURE RATE} = \frac{\text{TIME-BASED CM ACTIONS}}{\text{TOTAL OPERATE HOURS}} \quad \text{AND}$$

$$\text{CYCLIC FAILURE RATE} = \frac{\text{CYCLIC CM ACTIONS}}{\text{ROUNDS}} \times \frac{\text{ROUNDS}}{\text{HOUR}} \text{ (FIRING RATE)}$$

THE RATIO OF TOTAL CM ACTIONS WHICH ARE ATTRIBUTED TO CYCLES AND TIME IS DETERMINED FROM HISTORICAL DATA FOR THE GUN MOUNT.

RELIABILITY FUNCTION R(T)	THE PROBABILITY THAT THE EQUIPMENT WILL PERFORM ITS MISSION SUCCESSFULLY EXPRESSED AS A FUNCTION OF TIME.

$$R(T) = E^{-LT} \quad \text{WHERE} \quad L = \text{FAILURE RATE} = \frac{1}{\text{MTBCM}}$$

MAINTAINABILITY

DOWNTIME — EXPRESSED IN HOURS, CATEGORIES OF MEAN DOWNTIME ARE:

MEAN TIME TO REPAIR (MTTR) — AVERAGE AMT PER CM ACTION. TO ARRIVE AT A FINAL MTTR, TWO TYPES OF EVENTS ARE CONSIDERED:

1. MDCS CM ACTIONS WITH AMT REPORTED.
2. MDCS CM ACTIONS WITH NO AMT REPORTED.

$$MTTR = \frac{AMT(1) + AMT(2)}{MDCS\ CM\ ACTIONS}$$ WHERE

AMT(1) = TOTAL AMT ACTUALLY REPORTED IN MDCS.

AMT(2) = TOTAL ESTIMATED AMT FOR MDCS CM ACTIONS WITH NO AMT REPORTED. THE AVERAGE NUMBER OF PERSONNEL USUALLY WORKING ON AN EQUIPMENT (DETERMINED FROM MDCS HISTORY OR ENGINEERING ESTIMATES) IS DIVIDED INTO THE TOTAL MAN-HOURS FOR CM ACTIONS WITH NO AMT REPORTED.

PARTS

DELAYS FOR — TOTAL CM ACTIONS WHOSE CORRECTIONS WERE DELAYED DUE TO LACK OF PARTS. ALL DELAYS ARE MANUALLY ANALYZED.

MEAN DELAY TIME — $$\frac{\text{TOTAL TIME AWAITING PARTS}}{\text{TOTAL CM ACTIONS DELAYED FOR PARTS}}$$

THE TWO CATEGORIES OF DELAY TIME DUE TO LACK OF PARTS ARE:

MDCS - THE DIFFERENCE MINUS AMT BETWEEN THE DEFERRAL DATE FOR LACK OF PARTS (ACTION TAKEN CODE 7) AND THE EARLIER OF (1) THE DATE THE FIRST NOT-IN-STOCK PART WAS ISSUED OR (2) THE DEFERRAL CLOSING DATE.

CASREPT - SUPPLY DOWNTIME REPORTED ON THE CASCOR MESSAGE.

OUTSIDE ASSISTANCE

DELAYS FOR — TOTAL CM ACTIONS THAT COULD NOT BE CORRECTED BY THE SHIPS' FORCE DUE TO LACK OF SKILLS, INSUFFICIENT EQUIPMENT, FACILITIES, FUNDS, ETC. ALL DELAYS ARE MANUALLY ANALYZED.

MEAN DELAY TIME

$$\frac{\text{TOTAL DELAY TIME FOR OUTSIDE ASSISTANCE}}{\text{TOTAL CM ACTIONS DELAYED FOR OUTSIDE ASSISTANCE}}$$

THE TWO CATEGORIES OF DELAY TIME FOR OUTSIDE ASSISTANCE ARE:

MDCS - THE DIFFERENCE BETWEEN THE DATE OF DEFERRAL FOR OUTSIDE ASSISTANCE (ACTION TAKEN CODE 8) AND THE COMPLETION DATE OF THE CLOSING DOCUMENT MINUS AMT.

CASREPT - WHEN THE CASREPT INDICATES AN ASSISTING ACTIVITY WAS INVOLVED (REPAIR ACTIVITY CODES R, T, O, AND D), THE TIME DELAYED FOR OUTSIDE ASSISTANCE EQUALS THE DIFFERENCE BETWEEN THE CASREPT AND CASCOR DATE TIME GROUPS MINUS SUPPLY DOWNTIME AND ESTIMATED AMT.

SHIPS' OPERATIONS

DELAYS FOR

TOTAL CM ACTIONS WHOSE CORRECTIONS WERE DELAYED DUE TO SHIPS' FORCE WORK BACKLOG OR OPERATIONAL PRIORITY. ALL DELAYS ARE MANUALLY ANALYZED.

MEAN DELAY TIME

$$\frac{\text{TOTAL DELAY TIME FOR SHIPS' OPERATIONS}}{\text{TOTAL CM ACTIONS DELAYED FOR SHIPS' OPERATIONS}}$$

THE TWO CATEGORIES OF DELAY TIME FOR SHIPS' OPERATIONS ARE:

MDCS - THE DIFFERENCE BETWEEN THE DATE OF DEFERRAL FOR SHIPS' OPERATIONS (ACTION TAKEN CODE 6) AND THE COMPLETION DATE OF THE CLOSING DOCUMENT MINUS AMT.

CASREPT - WHEN THE CASREPT INDICATES THE SHIPS' FORCE CORRECTED THE CASUALTY (REPAIR ACTIVITY CODE S), THE TIME DELAYED FOR SHIPS' OPERATIONS EQUALS THE DIFFERENCE BETWEEN THE CASREPT AND CASCOR DATE TIME GROUPS MINUS SUPPLY DOWNTIME AND ESTIMATED AMT.

MEAN DOWNTIME (MDT)

$$\frac{\text{TOTAL DOWNTIME}}{\text{TOTAL CM ACTIONS}}$$ WHERE

TOTAL DOWNTIME IS THE SUM OF AMT AND DELAY TIME FOR LOGISTICS, OUTSIDE ASSISTANCE, AND SHIPS' OPERATIONS, MINUS CONCURRENT DOWNTIME FOR MORE THAN ONE CM ACTION IN THE SAME SERIAL - NUMBERED EQUIPMENT.

MAINTAINABILITY FUNCTION M(T)

THE PROBABILITY OF COMPLETING A CORRECTIVE MAINTENANCE ACTION WITHIN A SPECIFIED TIME (T).

$$M(T) = \frac{\text{ALL MDCS CM ACTIONS WITH AMT LESS THAN OR EQUAL TO T}}{\text{MDCS CM ACTIONS}}$$

AVAILABILITY

INTRINSIC AVAILABILITY A(I)

THE PROBABILITY THAT AT ANY POINT IN TIME THE EQUIPMENT WILL PERFORM ITS SPECIFIED FUNCTIONS WHEN USED IN AN IDEAL SUPPORT ENVIRONMENT (i.e. TOOLS, PARTS, MANPOWER, ETC. ARE AVAILABLE).

$$A(I) = \frac{\text{TOTAL OPERATE TIME}}{\text{TOTAL OPERATE TIME + TOTAL AMT}}$$

OPERATIONAL AVAILABILITY A(0)

THE PROBABILITY THAT AT ANY POINT IN TIME THE EQUIPMENT WILL PERFORM ITS SPECIFIED FUNCTIONS WHEN USED IN AN ACTUAL ENVIRONMENT.

$$A(0) = \frac{\text{TOTAL OPERATE TIME}}{\text{TOTAL OPERATE TIME + TOTAL DOWNTIME}}$$

USE AVAILABILITY A(U)

THE PROBABILITY THAT AT ANY POINT IN TIME THE EQUIPMENT WILL PERFORM ITS SPECIFIED FUNCTIONS OR IS CAPABLE OF DOING SO ON DEMAND WHEN USED UNDER STATED CONDITIONS INCLUDING AN ALLOWABLE WARNING TIME. A(U) IS SOMETIMES CALLED THE FLEET STATUS INDEX.

$$A(U) = \frac{\text{TOTAL UPTIME}}{\text{TOTAL UPTIME + TOTAL DOWNTIME}} \quad \text{WHERE}$$

TOTAL UPTIME = CALENDAR TIME MULTIPLIED BY ACTIVE EQUIPMENT POPULATION MINUS DOWNTIME WHEN THE EQUIPMENT IS TOTALLY INOPERABLE (STATUS 2 MDCS CM ACTIONS AND CASREPTS) AND TIME IN NON-AVAILABLE EMPLOYMENTS.

BEST AVAILABLE COPY

APPENDIX N

BIBLIOGRAPHY

1. Haggerty, John K., Maynard, John J., and Koening, L.A., "Application Factors for Thyristor Converter DC Motor Drives", *IEEE Transactions on Industry and General Applications,* Vol. IGA-7, No. 6, pp. 718-728, November/December 1971.

2. Jacobs, Alan P. and Walsh, George W., "Application Considerations for SCR DC Drives and Associated Power Systems", *IEEE Transactions on Industry and General Applications,* Vol. IGA-4, No. 4, pp. 396-404, July/August 1968.

3. Johnson, William P., "Transient Voltage Sources and Effects on on Electrical Equipment", *IEEE Transactions on Industry Applications,* Vol. 1A-9, No. 3, pp. 332-335, May/June 1973.

4. Stevenson, John, "Leakage Current from Appliances", *IEEE Transactions on Industry Applications,* Vol. 1A-9, No. 1, pp. 74-80, January/February 1973.

5. Sperow, Leon H., Chairman, Fuse Application Group of the Power Semiconductor Committee, IEEE Industry Applications Society, "Fuse Selection for Power Semiconductor Conversion Equipment", *IEEE Transactions on Industry Applications,* Vol. 1A-9, No. 1, January/February 1973.